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CONTENTS

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THE SCIENTIFIC MONTHLY

OCTOBER, 1918

WEATHER CONTROLS OVER THE FIGHTING DURING THE SUMMER OF 1918[1]

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IT is obvious that so violent and so critical a series of military operations as those which have been taking place in the western war zone should, as a whole, continue in spite of temporary adverse weather conditions. It is, nevertheless, true that the student of military meteorology finds many noteworthy illustrations of weather controls even during the summer, which is meteorologically the most favorable season of the year for campaigning on the western front. It is to be borne in mind that the Germans had every reason for putting forth their utmost efforts during the spring and summer of 1918, in order, if possible, to gain a decisive victory before the winter should put a stop to active fighting, and before the spring of 1919 should bring the Allies a distinct superiority in man-power owing to the expected arrival of very large numbers of American troops.

May ended and June began with a spell of fine summer weather. The sun was hot, and the roads were deep in dust, which rose like smoke under the feet of the marching troops. Rains, the heavier and the longer-continued the better, were greatly to be desired by the Allied armies. For rain means mud, water-soaked bogs and swamps, and water-filled shell-craters. And rain and mud mean difficulties in the transportation of guns, of ammunition and of supplies. During the German offensive, early in the summer, delays of this sort interfered with the prompt execution of the enemy's carefully-laid plans, and gave added time for the Allies' reserves to gain in strength. Later on, when the enemy was making his forced retirements, bad weather and difficult transportation made it very

[1] Continued from the July, 1918, number of THE SCIENTIFIC MONTHLY.

much harder for the Germans to move back their artillery and ammunition, an enormous amount of which fell into the hands of the Allies. Mr. Philip Gibbs put the case very clearly in a despatch cabled to the New York *Times*.

> Last year in Flanders the rain, that began in August and hardly ceased until the end of November, created such foul conditions for the British troops that rapid progress in attack was utterly impossible, in spite of courage and will power reaching to the very heights of human nature. That was the British tragedy and German luck. Now, for the great offensive in the west, the enemy has again been favored by the weather. All through February and March, when the German armies were massing and making secret preparations for the assault on our line, the days and nights were dry and mild; the ground firm; the roads good, and all conditions favorable for the movement of men and guns. It has lasted like that ever since, with hardly a break, and the splendor of the last two months has given the enemy all the advantage for his plans and organization of attack.

A heavy rain storm on June 9 and 10 was noted as having temporarily delayed the Germans during a new advance, but another spell of fine weather immediately followed, again favoring the enemy by keeping the ground hard and dry. The New York *Times* correspondent, under date of June 13, cabled "the weather still holds good, but if the deluge comes it will for once be in our favor, and the more mud the merrier." After the middle of June (19th to 24th) there was about a week of showery, cloudy weather, but the month ended, and July began, with a spell of fine weather, interrupted, after the usual summer fashion, by showers or thunderstorms, which are noted as having benefited the French crops.

A new German offensive was launched on the morning of July 15. This had been expected for many days. As in previous instances of starting an enemy offensive, it is probable that the time was carefully chosen as a favorable one on the advice of the German meteorological experts, of whom there are reported to be sixty at the front.

The dominant fact in the later portion of the summer campaign was the steady and at times rapid retreat of the German armies. In this retreat, as above noted, rain and mud played an important part. As one correspondent put it (July 23), "there was a heavy rain to-day in the north of France, and each drop of it will alter a little, perhaps, the history of this war.... So let it rain."[2] Obviously, bad weather and deep mud also retarded the advance of the Allies, and hampered their artillery fire, as, *e. g.*, during the first week of August. The enforced abandonment of immense quantities of ammunitions and

[2] Philip Gibbs, in the *New York Times*.

supplies and of many heavy guns by the enemy was, however, a far more critical result of the meteorological conditions. The high water stages of the French rivers were a serious factor for the enemy to deal with. Recent rains had caused a flooding of the Vesle. The German rear-guards could not ford the river and had to fight for their lives. Most of them were killed, and the rest were taken prisoners. The rise of the river seems to have disorganized the whole German plan for protecting the withdrawal of the army. On the other hand, one despatch noted the fact that the Germans also were favored by the weather, which "transformed the banks of the Vesle into swamps and morasses," enabling the enemy to make "a stiffer stand here than was to be expected." The rains, swollen rivers and mud of the first week of August, which retarded the Allied pursuit and prevented them from bringing up their guns, ammunition and supplies, were probably a more important factor in slackening the Allied advance than was the resistance offered by the Germans.

Many illustrations might be given of the part played by weather conditions in local engagements. Thus, a German surprise attack, to regain Bouresches, was made on a dark cloudy night (June 13), but had been anticipated by the American troops who realized that the weather was ideal for just such an attempt. A French-American counter-attack along a broad front on the early morning of June 18 was wholly unexpected by the enemy, who had been driven to shelter in his dugouts by a violent thunderstorm which burst shortly after midnight. The noise of the storm drowned out the noise of the Allied barrage fire, and the Allied tanks took up their positions unnoticed. The frequent night fogs of the western front have often played a part in the fighting. On July 15, the Germans on the north bank of the Marne advanced at dawn under cover of a fog. Again, on July 30, a heavy fog favored a German attack on the north bank of the Ourcq. An important combined British and French attack on the German lines between Amiens and Montdidier caused the enemy to retreat on the first day over a front of more than 20 miles. This attack took the enemy completely by surprise. A thick fog had begun to form early the night before, and by dawn had completely covered not only the valleys but the higher ground also. At daylight, the fog "lay so thick it was impossible to see more than 30 yards" in any direction. Following a short but intense artillery preparation, the Allied troops advanced through the fog, taking the enemy completely by surprise. The men in advance of the attacking troops "were met only by rifles and machine guns, firing vaguely

through the fog." By nine o'clock in the morning the fog was lifting, but the enemy was in retreat. At dawn on August 21, the British smashed into Gen. von Below's seventeenth army during a heavy fog, on a front extending more than ten miles from the Ancre River to Moyenneville. The infantrymen and the tank crews "could scarcely see 100 ft. ahead of them." The fog was most favorable to the attacking troops, for it effectively concealed them from the eyes of the enemy, who suffered heavy casualties and lost many guns. Some of the British tanks and battalions are reported to have lost their direction, and this led to some confusion, but the advantages due to the fog were far greater than the disadvantages.

In mid-August (14th) "glorious weather" was reported on the Picardy battlefront. The Allied airplanes were able to observe the enemy's movements, and to know where he was concentrating his reinforcements. "Stifling weather" prevailed during most of the fighting around Lassigny (third week of August). The men fought "under a scorching sun"; stripped to the waist. Heavy rains fell late in August, but, in spite of this handicap, the Allied troops pressed on in their general advance.

A part of the responsibility which the United States is taking in the war is the increasing contribution which we are making to the Allied military meteorological service overseas. Several expert meteorologists, commissioned as officers of the Signal Corps, have been in France for some time. Three hundred Army meteorological observers, especially selected, and trained for their work at the Agricultural and Mechanical College of Texas, have recently been sent abroad. The War Department, it is announced, plans to train 1,000 men in all for this highly important service. Once a day a summary of weather conditions over the United States is cabled from Washington to the Headquarters of the American Expeditionary Force in France. The regular forecasts of weather conditions on the western front, based in part upon these observations, are now regularly used by American officers in planning airplane activity, artillery work, and military operations generally. In connection with meteorological activities overseas, it is significant that Sir Napier Shaw, who has for nearly fifteen years been director of the British Meteorological Office, has recently been appointed scientific adviser on meteorology to his government, for the duration of the war.

Although the summer has only just ended, the need of keeping the American troops overseas warm during the damp and chilly autumn and winter months has already been given serious

attention. That the lack of an adequate fuel supply in France will lead to much suffering on the part of the men is inevitable. Although many of the American troops are accustomed to much greater outdoor cold at home than they will ever experience on the western front, they are used to *dry* cold, and to warm houses.

The Austrian drive began June 15. Offensive operations had been attempted several times in the late spring, but the lingering snows of winter, snowslides, and deep-flowing mountain torrents prevented any large scale campaigning. A June 7 despatch had referred to the Austrian "spring drive" as imminent, the floods in the Piave, resulting from melting snows, having subsided, but bad weather on June 13 was reported as still hindering operations. The morning selected for the Austrian advance was "more than usually" foggy in the mountain sector. The snow still lying in the mountains was "heaped up into immense mounds by the bombardment," and the Italian troops wore white overalls as a protection in the snow. Bad weather during the next three days limited operations, and the heavy rain helped to minimize the effects of the gases, which were used in large amounts by the Austrians.

The most striking meteorological factor during the whole summer campaign on the Austro-Italian front was the flooding of the Piave River within a few days after the Austrian advance across it. This flood, the result of the heavy rains which fell for about a week in the mountains and on the Venetian lowland, turned the river from a by no means formidable military obstacle into a rushing torrent. Thirteen out of fifteen pontoon bridges built by the enemy were swept away. It thus became extremely difficult, if not altogether impossible, to supply such of the Austrian troops as had crossed to the western bank (reported as numbering about 40,000) with reinforcements, artillery, ammunition and food. In fact, the troops on the western bank were soon completely isolated, such bridges as were not swept away by the flood being bombed by British and Italian aviators. One report noted that the isolated Austrians were for a time fed by means of airplanes. In the face of persistent Italian counter-attacks, with their bridges washed away or destroyed, and all efforts to rebuild them proving futile, the enemy was obliged to recross the raging Piave under the most difficult and dangerous conditions, in great disorder, all along the line from Montello to the sea. Thousands of the enemy were drowned, or shot in the water. The Austrian loss was put at about 200,000 killed, and 20,000 taken prisoner. The defeat of the enemy on the west bank was complete, and the Italian line was restored up to the water's edge. The Austrian War

Office, under date of June 24, announced: "A position has arisen by reason of the height of the water, and bad weather, which has caused us to evacuate Montello and some sectors of the other positions which we had won on the right bank of the Piave." Answering criticisms on the subject of the retreat, made in the Hungarian Parliament on June 29, Major Gen. von Szurmay, Minister of National Defence, said: "No one could have foreseen the heavy rain which caused the Piave to rise."

It is, however, manifestly unfair to the splendid work done by the Italian armies to leave the impression that the Piave floods alone were responsible for the Austrian retreat. The enemy's advance was doubtless checked before the floods began. The latter, however, made it impossible for the Austrians to keep anything that they had previously gained on the west bank. It was natural enough that the Austrians should have attributed their defeat to nature, and not to their opponents. Thus, a war correspondent of the Vienna *Neue Freie Presse* (July 2) said, "not the Italians, but the rain triumphed. Nature," he continued, "interposed its inexorable and cruel veto."

There is little to record regarding the operations in the Balkans. Bad weather was stated in several of the early summer despatches to be responsible for the inactivity. Regarding the Allied operations in Albania, a Paris War Office despatch of July 24 said: "Our attacks have succeeded by reason of perfect preparation and the bravery of our troops, who, in the course of engagements carried out sometimes in snowstorms and sometimes under an unbearable sun in a very difficult country, have by their skill and resolution taken indisputable ascendency over their adversary."

The important war activities on the former eastern (Russian) front have been in connection with the landing of Allied troops on the Murman Coast. This northern region gains its chief importance because it has an ice-free port, the result of the presence of a warm ocean current (Gulf Stream drift) alongshore. From this port, a railroad of strategic value runs to Petrograd.

No large-scale military operations have been reported from Mesopotamia, where the heat of the summer is such as to make active campaigning extremely difficult and dangerous. In spite of many climatic and topographic handicaps, however, a British force succeeded in reaching Baku early in August, but details of this march are not yet available. They will be of very unusual interest when they are made public. As fuller information comes to hand regarding the earlier operations in Mesopotamia, the extraordinary difficulties under which the British Expedi-

tionary Force has been carrying on its important and almost forgotten advance in that land of heat, and dust, and floods, stand out in a clearer light. No correspondent has had a better opportunity to see what has actually been accomplished by the British forces in Mesopotamia than Mrs. Eleanor Franklin Egan, whose admirable articles in the *Saturday Evening Post* have given a vivid and accurate picture of the country itself, as well as of the activities of the British Expedition. Mrs. Egan notes that in a book of instructions to British officers regarding equipment for Mesopotamian service the following advice is given: "To spend a year in this detestable land you will require three outfits of clothing—one suitable for an English winter; one suitable for an English summer, and an outfit suitable for Hades." In Mesopotamia, "climate gets more attention than any other one thing, and it is the first thing to be taken into consideration in every move that is made." During the late spring, summer and early fall, temperatures of over 110° F. are regularly reached, and under canvas the thermometer often reaches 130°. No records are available of the loss of life due to the heat during the first campaign in 1915, when no adequate preparations to meet this inevitable emergency had been made, but in the summer of 1917, 519 men of the Expeditionary Force died of heat and sunstroke, in spite of every possible precaution. Ice plants are now provided wherever there are British troops. Every hospital has a special sunstroke hut or tent which is always kept ready for the instant treatment of all cases. Sun helmets and "spine pads" must be worn throughout the hot months, and not until some time late in November do the orders of the day give the British soldier permission to leave these off after four o'clock in the afternoon.

In striking contrast with the intense heat and dryness of the Mesopotamian summer are the spring rains, and the floods resulting from the melting snows far up in the Armenian mountains. These floods, spreading far and wide over the lowlands, played an important part in the early days of the expedition, and are to be expected every year at about the same time. "Nobody who has ever lived through a spring and early summer in Mesopotamia," says Mrs. Egan, "doubts the story of the Flood." Another meteorological feature of this desert, as of other deserts, is the mirage. In the early days of the Mesopotamian campaign there was one engagement in which a mirage played a conspicuous part in turning the fight to the advantage of the British. The latter were being hard pressed. Their commanding officer was on the point of ordering a retirement, when suddenly the enemy were seen to be in full retreat. The Turkish

commander, deceived by a mirage, saw what seemed to him to be heavy British reinforcements approaching, and directed his troops to retreat at once. It was only a British supply and ambulance train, "magnified and multiplied by the deceptive desert atmosphere." The Turks stampeded, and were pursued by bands of nomadic Arabs for a distance of nearly ninety miles across the desert. It is reported that the Turkish commander discovered his mistake a few days later, and committed suicide.

From Palestine there have been no reports of either military or meteorological interest. Doubtless there, too, military activity has been greatly curtailed by the heat and drought of the summer. One belated communication, from Jerusalem, notes the fact that the winter (1917–18) was "long and cold—so the poor Tommies think. But it has been the best winter since the war set in. We have had no snow."

In aviation, it is increasingly evident that weather conditions which earlier in the war were regarded as prohibitive for flying, are now interfering less and less, at least so far as bombing is concerned. High winds, low clouds and fog, and heavy rain, decidedly lessen aerial activity, and spells of fine weather always greatly increase it, yet month by month, as the reports come in, it is evident that in the intensity of this modern warfare, flying must be done in practically all weather. Nevertheless, aerial reconnaissance and photography, and direction of artillery firing from airplanes, can not be effectively carried out unless there is a reasonably clear view of the ground. The advantage which the prevailing westerly winds give to the enemy aviators on the Western Front is readily recognized. A London despatch, dated July 23, notes that

> the weather admittedly plays an important part in the defense of England against German air raids. The time will shortly arrive when more or less settled conditions can be expected to prevail, and with the approach of that date speculation grows keen as to what "the long-range bombing season" is likely to bring forth.

One of the new developments in aviation is "cloud formation flying," which has been decribed by Brig. Gen. Charles Lee, of the British Aviation Mission now in this country.[3] "Cloud flying is to-day a necessity," although until recently pilots have hesitated to go into clouds except for defensive purposes. The machines go in formation through the clouds, meeting again above the clouds. There the formation is continued on a compass bearing to the objective. The machines then come down through the clouds; bomb the objective; go up again, and come home.

[3] *New York Times*, August 18, 1918.

The use of gas shells, instead of the clouds of chlorine gas which the Germans so generally employed in the earlier days of the war, has in no way overcome the importance of the wind direction as a factor in a successful gas attack. There are several reports of a change of wind during a gas attack, which drove the gases back to the enemy lines. On June 10, on the western front, "the wind changed its direction, and tens of thousands of poison gas shells fired by the Germans did more damage to themselves than to the Allies." On July 15, a Paris despatch noted the favorable weather conditions which prevailed for the Allied armies.

> For once the Germans are not favored by the elements. The sky is overcast, the weather is unsettled, and, most important, the wind is southwest. This is a vital gain for the defense, for it makes it difficult, if not impossible, for the Germans to make extensive use of gas, on which they usually count. Cohesive action is out of the question when troops are muzzled for long hours with masks. Officers can not communicate orders, and each man is thrown on his own resources. As a result, weight of numbers, which is always on the side of the attacking army at the beginning, becomes the deciding factor.

Again, on August 6, in the Fismes sector, a change of wind to the south blew the gas back from the American lines and towards the enemy.

In connection with gas attacks in general it is worth recording that at the very beginning of the use of gas clouds the importance of a knowledge of the wind direction was recognized by the British and French troops in the trenches. Various devices were employed to serve as wind vanes. Anything that could easily be seen by the enemy naturally drew fire. A simple vane was then devised, consisting of a stick with a thread about a foot long fastened at the upper end of it, and with a small piece of cotton wool at the end of the thread. The strength of the wind was indicated by the rise of the cotton wool from a vertical position. Night was soon found to be the best for chlorine gas attacks, because the moving air then has a greater tendency to flow down any slopes, and to keep the gas cloud near the ground. By day, on the other hand, the general tendency of the air is upward, and this is likely to dissipate the gas.

The question of the most favorable weather conditions for the use of gas, and for general military operations on the western front, is one which can easily be answered by any one who has some knowledge of European weather types. The Germans want a weather type distinguished by high pressure over northern or northeastern Europe. This gives them clear skies, and generally light *easterly* winds, blowing toward the Allied lines. This is a fairly "settled" weather type. It comes on slowly, and the German meteorological experts, with the help of

such weather maps as they are able to construct, can usually predict the continuance of this weather type for several days. This is, doubtless, one of the principal reasons why the Germans have on the whole so distinctly had the best of the weather situation ever since the war began. On the other hand, the Allies on the western front need southwesterly winds for their gas attacks. These usually occur during the passage of an area of low pressure; are therefore apt to be of fairly high velocity, and to be accompanied by clouds and rain. Furthermore, this type is characteristically of rather short duration. The advantage in this matter thus clearly lies with the Germans. At the end of August it was noted that the Germans were using little gas because the wind was unfavorable.

The destruction, by Commander Rizzo, of an Austrian battleship[4] off the Dalmatian coast early in June was favored by a fog, which prevented the attacking Italian motor boats from being seen as they worked their way through the screen of enemy destroyers. In our own waters, the German submarine which attacked an ocean-going tug and its convoy of barges off Cape Cod on July 21 approached unseen in a fog.

The importance of the food supply of Germany as a factor in the duration of the war gives interest to all reports regarding the German and Austrian crops, although too much weight should certainly not be laid on the cabled news. An Amsterdam despatch of June 7 mentioned a "sudden cold wave" over Central Europe, with severe frosts, which caused widespread damage to grain, fruit and potatoes. In a despatch from London, June 27, reference is made to *snow* from one to three inches deep in several parts of Germany. From Zurich, July 5, a report comes of violent rain-storms and abnormally low temperatures in Austria-Hungary, with "severe snowstorms and frost in Bosnia, Herzegovina and Dalmatia." The snowfall continued for several hours, and greatly damaged the crops. It may be noted in connection with these reports of snow in summer, that brief snowfalls, coming chiefly in thunderstorms, are not uncommon on mountains and high plateaus, even in the hottest season of the year. Later Amsterdam and Zurich reports (July 8 and 10) mention severe floods in many parts of Austria and Southern Germany. The Danube at Vienna reached the highest level in thirty years. A more detailed report (July 22) notes that in Germany spring drought and heat were followed by frosts early in June, one third of the potato crop being killed and other vegetables and fruits being severely affected. Trade reports generally agreed in saying that the crop outlook in both countries was unfavorable.

[4] Probably two battleships were destroyed.

IDENTIFICATION OF INDIVIDUALS BY MEANS OF FINGERPRINTS, PALMPRINTS AND SOLEPRINTS

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A FINGERPRINT may be defined as an impression from the ridge crests of the friction-skin of the ventral surface of a digit. As the terminal phalange is the only one constantly exhibiting a "pattern" configuration, it is the one utilized for making identification records, although an identification may as accurately be made from an impression of either remaining phalange, or the palm of the hand or the sole of the foot. An impression may be naturally or artificially made. By "naturally" is meant the absence of any transfer medium other than nature's perspiration residuum. A natural print is also sometimes called a "latent" print, because it is often invisible, and, to make a permanent record available for inspection and comparison, it must be visualized and fixed by one of the usual methods. A natural print may be intentionally or unintentionally made.

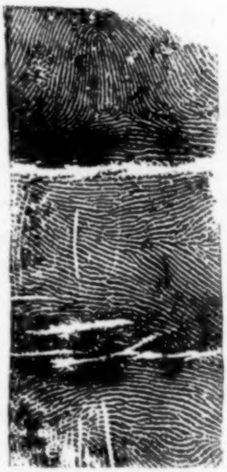

FIG. 1. A *rolled* digital impression. The apical portion is the "fingerprint" of commerce.

An artificial impression may be intentionally or unintentionally made, but the medium for recording it is externally applied and is not nature's skin excretions; for example, paint on the hand of a painter; grease on a mechanic's hand; blood on the hand of a butcher; ink on a printer's hand; or the surface is purposely inked as in commercial and institutional spheres. Artificial impressions made with oil, cold cream or other invisible medium must be visualized and fixed as are latent prints.

Mechanically, there are two kinds of fingerprints: *plain* and *rolled*. The *plain* impression is the one used exclusively by the Chinese, by Purkenje, and later by Herschel. This is made by placing the bulb of the finger flat upon the inking surface

and then upon the receiving surface, the resulting impression being elliptical in shape, the long axis being that of the finger itself. The *rolled* impression is made by placing the digit on the inking surface, radial side in contact, the finger-nail perpendicular to the inking surface, then rolling the bulb of the finger until the ulnar side is in contact and the nail is again perpendicular but reversed in position. The bulb being thus inked, the same operations are repeated on a paper form suitable for recording the impression. This operation produces a cylindrical projection of the ventral surface of the digit which graphically delineates the ridge configuration in all its minutiæ.

Thus it will be seen that a friction-skin impression (finger, palm or sole) is a graphical record, by personal contact, of an external physical characteristic capable of being recorded for future reference. It possesses no occult powers of character revelation, but in its gross and minute features is so permanently individual that it is an unerring revealer of personal identity throughout one's lifetime and as long thereafter as the cutis is preserved.

Galton states that:

> With regard to the durability of the epidermic ridges they are still present and plainly seen in many Egyptian mummies.

Wilder says that:

> In an experiment made by him upon the feet of an infant belonging to the prehistoric cliff dwellers of Southern Utah, where bodies were not even embalmed, but simply dried in the rarefied mountain air, the thenar and apical patterns could be definitely traced after a comparatively simple preliminary treatment.[1]

The evolution of the use of the fingerprint and palmprint for personal identification, from the superstitious ceremonial of the ancient Chinese to the refined science of to-day, is, strange to say, a matter of the last sixty years, especially the last thirty years, since Sir Francis Galton placed the fingerprint, and Dr. Harris Hawthorne Wilder, zoologist, placed the palm- and soleprints upon firm scientific foundations. For the Oriental history of their use the reader is referred to Galton's "Finger Prints," Chapter II., and to Mr. Berthold Laufer's "History of the Fingerprint System" (Smithsonian Report, 1912, pp. 631–652). Reading these together, it would seem that the potency of a finger- or palmprint lay more in the ceremonial factor of personal contact necessary in making them, together with the fear of the consequences following a repudiation of a mark so solemnly made, than in any realization of

[1] Dr. H. H. Wilder, "Scientific Palmistry," Pop. Sci. Mo., November, 1902, p. 53.

their inherent individuality. Yet a desire or intent to identify through their use is evident, for their language contained words expressing the act "to identify," also nouns indicating the patterns we call the "whorl," "loop" and "arch."[2] But such identifications were evidently accomplished by written description in the case of babies in foundling homes,[3] and by smudgy and indifferent prints for adults, each verified, evidently without the use of the magnifying lens, as it probably at that early date had no general commercial distribution, if indeed it were known outside of educated and wealthy circles.[4] Therefore,

[2] Laufer, Smithsonian Report, 1912, p. 639 and footnote.

[3] *Ibid.*, p. 639, ". . . There follows a description of the bodily parts including remarks on the extremities, formation of the skull, crown of the head, birth marks, and design on the fingertips, for later identification. . . . Each Chinese mother is familiar with the finger marks of her newborn." The quality of this "familiarity" may be better imagined after examining the next newborn without a magnifier.

[4] "Lenses, Their History, Theory and Manufacture," *Optical Journal*, Vol. XIX., May, 1907, page 644, by Mr. J. J. Bausch and Mr. Henry Lomb.

In this historical sketch no indication of Oriental genesis or use is made. The first use of spectacles is placed at about 1285, the invention of d'Armato, of Florence. In Part II., page 728, "Lenses, among the Ancients," they say:

"In point of antiquity lenses as aids to imperfect vision lead all others . . . and still they are comparatively modern, for although we have no authentic records, the consensus of opinion seems to place the invention of spectacles in the thirteenth or fourteenth century. We can say with certainty that the Greeks and Romans of antiquity were unacquainted with glass lenses of long focus, nor do the larger collections in European museums contain any examples, although there have been found in various places convex lenses of short focus made of glass or of rock crystal. There was found in a grave in Nola a plano-convex piece of glass about 4.5 cm. diameter mounted in gold; in Mayence one of 5.5 cm. diameter; a similar one in Pompeii; a bi-convex one in England; finally the oldest lens we have, a plano-convex lens found in Ninevah, of rock crystal. . . . It is remarkable that all these are convex lenses. The fact that lenses have been so seldom found, that the one is mounted in gold, leads to the assumption that they were the rare possessions of wealthy and prominent people. While these lenses were not spectacle lenses in our sense because of their short focus, still we are forced to assume that they were used as burning and magnifying glasses. Passages in Plinius and Seneca show us that the Greeks and Romans were well acquainted with the magnifying power of a globe filled with water, but they ascribed to the water, not to the curved surface, the fact that by means of such an object they could decipher small illegible script. . . . Cicero mentions an 'Iliad' of Homer written on parchment which was comprised in a nutshell. Pliny tells that a Milesian executed in ivory a square figure which a fly covered with its wings. Unless their vision surpassed that of the most skilful modern artists these facts prove that the magnifying power of lenses was known to the Greeks and Romans two thousand years ago."

an identification must have contemplated, in the case of babies at least, only the most superficial resemblance between two "tou" (whorls), or two "ki" (loops), or two "lo" (arches). Of course an arch could be distinguished from a whorl or a loop without a magnifier, but to distinguish between two arches for instance, having a degree of likeness closely approximating identity (see Fig. 10 *a* and *b*), the absence of the magnifier would certainly preclude any such accurate discrimination as is absolutely necessary to-day. Aside from the prints themselves, this absence of any realization of and reliance upon the individuality of the friction-skin configuration seems clearly shown by Rashidudden, the famous Persian historian, who wrote in 1303 as follows (extract from "Cathay," by H. Yule, Vol. III., p. 123):

> Extracted from the Historical Cyclopedia of Rashidudden. . . .
>
> Lastly, the business arrives at the sixth board, which is called Siushtah. All ambassadors and foreign merchants when arriving and departing have to present themselves at this office, which is the one which issues orders in council and passports. . . .
>
> When matters have passed these six boards, they are remitted to the Council of State, or Sing, where they are discussed, and the decision is issued after being verified by the Khat Angusht or "finger-signature" of all who have a right to a voice in the Council. This "finger-signature" indicates that the act, to which it is attached in attestation, has been discussed and definitely approved by those whose mark has thus been put upon it.
>
> It is *usual* in Cathay, when any contract is entered into, for the outline of the fingers of the parties to be traced upon the document. For experience shows that no two individuals have fingers precisely alike. The hand of the contracting party is set upon the back of the paper containing the deed, and *lines are then traced around his fingers up to the knuckles* in order that if ever one of them should deny his obligation this *tracing* may be compared with his fingers and he may thus be convicted.

Here the fingerprint is not even suggested, but a sort of ceremonial is used involving the five fingers, the desired psychic effect being accomplished by very formally tracing lines "around his fingers up to the knuckles," evidently such as the children of to-day trace in playing the game of *tit-tat-toe*. To us, this is a most crude method of identification, but it must have worked or it would not have been "usual," for the psychology of fear was doubtless as potent then as now, although perhaps not so clearly understood. At any rate, this ancient use of fingerprints, finger-outlines and handprints has none but historical interest for us. Nothing of any scientific value has as yet come down to us by virtue of its own worth or momentum as it were, *e. g.*, the silk worm and silk. Galton observes (1897):

No account has yet reached me of trials in any of their courts of law about disputed signatures, in which the identity of the party who was said to have signed with his fingerprint had been established or disproved by comparing it with a print made by him then and there.

Fifteen years later (1912) Mr. Laufer observes:

Indeed, it is striking that we do not find in any author a clear description of it and its application. The physicians in their exposition of the anatomy of the human body do not allude to it, and it is certain that it was not anatomical or medical studies which called it into existence. It formed part of the domain of folklore, but not of scholarly erudition.

In this connection Mr. Laufer makes (p. 645) an interesting citation from A. H. Smith's "Proverbs and Common Sayings from the Chinese," thus:

The Chinese, like the Gypsies and many other peoples, tell fortunes by the lines upon the inside of the fingers. The circular striæ upon the finger tips are called "*tou*," a peck; while those which are curved, without forming a circle, are styled "*ki*," being supposed to resemble a dust pan. Hence the following saying:

"One peck, poor; two pecks, rich; three pecks, four pecks, open a pawnshop; five pecks, be a go-between; six pecks, be a thief; seven pecks, meet calamities; eight pecks, eat chaff; nine pecks and one dust pan, no work to do—eat till you are old."

How different the contributory beginnings of the present-day scientific identification! It was *a physician* in his exposition of the anatomy of the human body who first called attention to the friction-ridge patterns—"M. Malpighi, 1686 A.D., quoted by Alix, 1867, and by Schlaginhaufen, 1905."[5] Again, in 1823, another physician, J. E. Purkenje, in a now famous thesis, partially translated by Galton, went still farther and described and classified the various ridge configurations as shown by "plain" impressions.[6] The late Sir William J. Herschel makes an additional citation from this thesis which is interesting; he says:

Referring to "the varieties of the tonsils, and especially of the papillæ of the tongue, in different individuals" (no mention of fingers) he finishes his sentence and his essay by saying: "From all of which (varieties) sound materials will be furnished for that *individual knowledge of the man* which is of no less importance than a general knowledge of him is, especially in the practise of medicine." Herschel adds: "No part of his essay conveys an inkling of identification by means of any of the individual varieties on which he always lays stress, not even his pioneer work in the classification of the markings on fingers."[7]

[5] Wilder, "Bibliography of Friction-skin Configuration," *Biological Bulletin*, Vol. XXX., No. 2, page 249.

[6] Galton, "Finger Prints," pp. 85–88 and plate.

[7] Herschel, "The Origin of Finger Printing," p. 35 (1916).

Concerning the labors of the late Sir William J. Herschel in the application of the idea of friction-skin identification, Sir Francis Galton, writing at a time when the facts considered were a matter of Galton's personal knowledge, states his conclusions thus:

> If the use of fingerprints ever becomes of general importance, Sir William Herschel must be regarded as the first who devised a feasible method for regular use, and afterward officially adopted it.[8]

No allusion is made to the "discovery"[9] of their use by Herschel, the emphasis being on "the first to devise a feasible method for their regular use." Galton had already cited their prior use in his introductory chapter, saying:

> The second chapter treats of the previous employment of fingerprints among the various nations, which has been almost wholly confined to making daubs, without paying any regard to the delicate lineations with which this book alone is concerned. Their object was partly superstitious and partly ceremonial: superstitious, so far as a personal contact between the finger and the document was supposed to be of mysterious efficacy; ceremonial, as a formal act whose due performance in the presence of others could be attested.[10]

Again in Chapter II.,

> Though mere smudges, they serve in a slight degree to individualize the signer. . . . The ridges dealt with in this book could not be seen at all in such rude prints, much less could they be utilized as strictly distinctive features.[11]

Read in connection with Galton's conclusions, Herschel's "Origin of Finger Printing" tells us how the idea of this as a "feasible method" developed in his mind, and gives the evolution of the method "for regular use." "There was nothing very original about that, as an idea," says Herschel, concerning his taking of Konai's handprint.[12] The change of method came quickly, but the idea of judicial sanction after "many years." Herschel says:

> Trials with my own fingers soon showed me the advantage of using them instead of the whole hand for the purpose then in view, *i. e.*, for securing a signature which the writer [maker] would obviously hesitate to

[8] Galton, "Finger Prints," Ch. II., p. 28.

[9] Herschel, "The Origin of Finger Printing," page 32. Here Herschel claims only the "discovery of the *value* of finger prints."

[10] Galton, introductory chapter, page 3.

[11] Galton, Ch. II., p. 23. Also Laufer's "History," Plate 3, showing two thumb smudges on a Tibetian promissory note. The print on Plate I., recorded as late as A.D. 1839, is reasonably clear. Its clearness may have been intentional.

[12] Herschel, "Origin of Finger Printing," page 8.

disown. [The old idea of fear again utilized.] That he might be infallibly convicted of perjury if he did, is a very different matter. That was not settled, and could not have been settled, to the satisfaction of courts of justice, till, after many years, abundant agreement had been reached among ordinary people [jurors?]. The very possibility of such a "sanction" to the use of a fingerprint did not dawn upon me till after long experience, and even then it became no more than a personal conviction for many years more.[13]

The researches of Sir Francis Galton were begun in 1880.[14] Their results were epochal. Pre-Galtonian prints were exclusively the "plain" impressions of to-day, amply sufficient for identification, but not for that precise classification so necessary for the modern Fingerprint Record File. Galton's introduction of the "rolled" impression or cylindrical projection of the finger; the utilization of the "minute triangular plot" or delta (Wilder's tri-radius) found in all rolled impressions (except that of the arch) as "corner stones" of his classification system; the substitution for a single "plain" impression of a complete series of ten rolled impressions, with plain impressions of the fingers as a check on printing the rolled impressions in proper sequence; together with his researches concerning the individual persistence of the ridge configuration (the results of which have been accepted as proof of persistency) made possible the present-day scientific systems of fingerprint identification. His conclusions on persistency have been amply confirmed by the late Sir William J. Herschel's series of impressions from two of his own fingers, the first taken in 1859, at the age of twenty-six years; the second, in 1877, and the third, in 1916, at the age of eighty-three years, a total interval of fifty-seven years, and, as he remarks:

For length of persistence they can not at present be matched.[15]

As Herschel gave of the fruits of his labors to Galton, so, in turn, Galton gave to Sir Edward Richard Henry, G. C. V. O., Commissioner of Police of the Metropolis, London, England, Sir Henry says:

In the system here described, many of his (Galton's) terms have been adopted, definitions accepted and suggestions followed whenever practicable.[16]

Upon this Galtonian foundation Sir Henry built the present

[13] Herschel, "Origin of Finger Printing," page 9.
[14] Galton, "Finger Prints," Ch. I., page 2.
[15] Herschel, "The Origin of Finger Printing," page 30.
[16] Henry, "The Classification and Uses of Finger Prints," 1913, page 5.

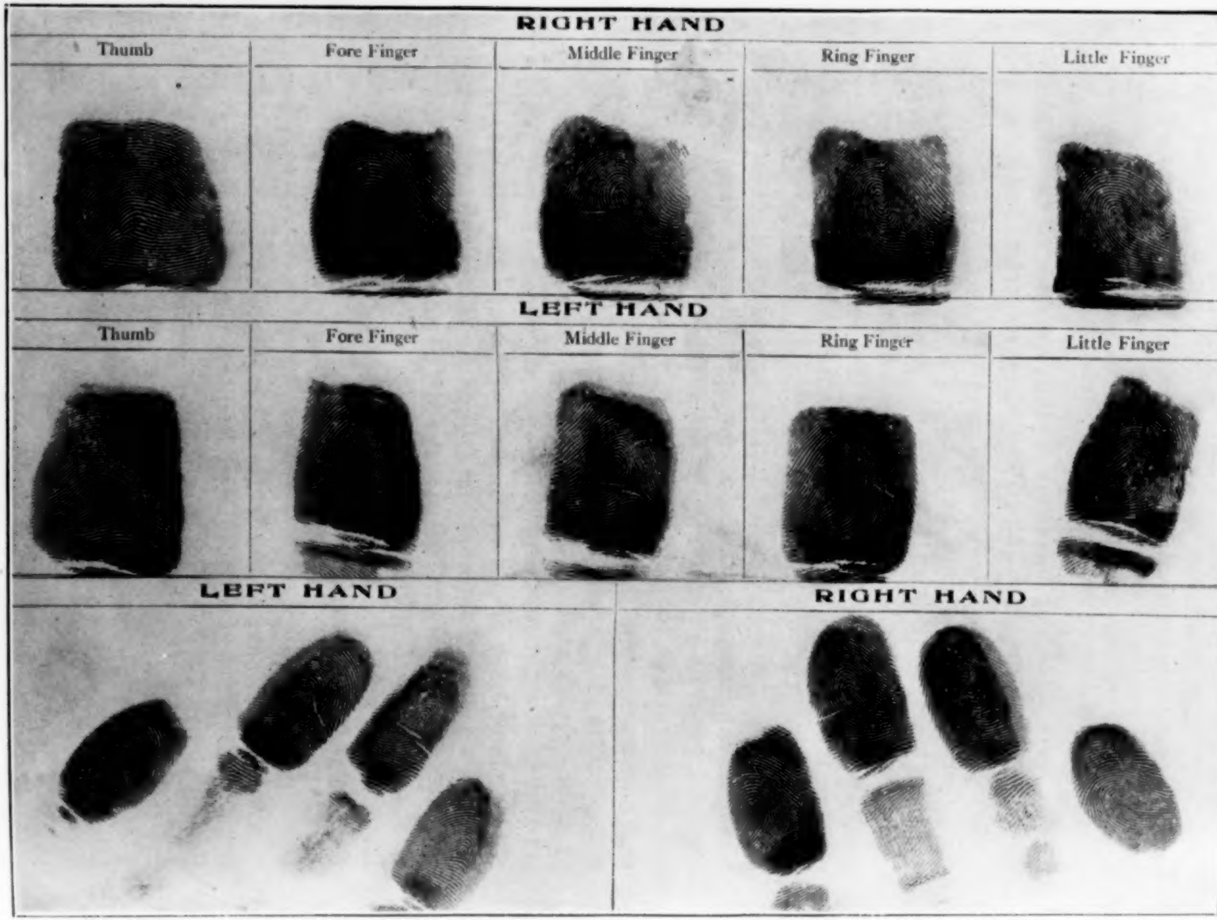

FIG. 2. A series of ten apical dermatographs (fingerprints) taken in conformity with the Henry System of Finger Print Classification.

extensively used Henry System of Finger Print Classification, which enables one familiar with its intricacies to make a set of ten apical impressions or dermatographs, classify it, and produce the person's history record (assuming one on file) in a period of time varying from five to fifteen minutes. Under this scientific system nothing is required of the subject save the set of ten apical dermatographs. Given this and nothing more, no name, no address, no physical description or photograph, the identifier "solves for x," to use an algebraic term. A record being produced, the subject's medical history, for instance, in the case of a hospital or clinic for the feeble-minded or insane, is at once available, no matter how long the interval between treatments, or the changed facial appearance of the subject, or similarity in names.

Galton in his "Finger Prints," Chapter IV, page 57, says concerning the ridges covering the palm of the hand and the sole of the foot:

> Having given but little attention to them myself they will not be again referred to.

Opposite, on Plate III., Fig. 6, are displayed four palm outlines and one showing the general configuration on both palm and fingers.

In this field of investigation Galton's mantle fell on one of his American correspondents (also a correspondent of Bertillon) who has confined himself to the palms and soles, and of whom it may fairly be said, to paraphrase Galton: If the use of palm- and soleprints ever becomes of general importance, Dr. Harris Hawthorne Wilder, zoologist, must be regarded as the first who devised a feasible method for their regular use and afterward promulgated it. In one of his first papers on the subject Dr. Wilder says:

> The great individual variation of these parts in the human being is not without significance and furnishes an excellent illustration of the *biological truth that the perfection and constancy of an organ are directly proportional to its necessity in the life of the organism* . . . that only useful and important parts retain a certain normal form in the various individuals of a given species, and that, as they become of less importance, they tend more and more to *vary individually*, the range of variation increasing with time and the degree of uselessness, if such an expression may be allowed; conversely, an organ that is seen to possess marked individual variation is shown to be of secondary importance, and may be either a rudimentary organ, that is one on the way towards a greater usefulness in the future and in which the variations represent the numerous experiments or attempts to find the form best adapted for a special purpose, or, again, it may be a vestigial organ, or one in which its point of usefulness

is passed and in which the variations represent various degrees of degeneracy, or stages in its gradual eradication from the organism.[17]

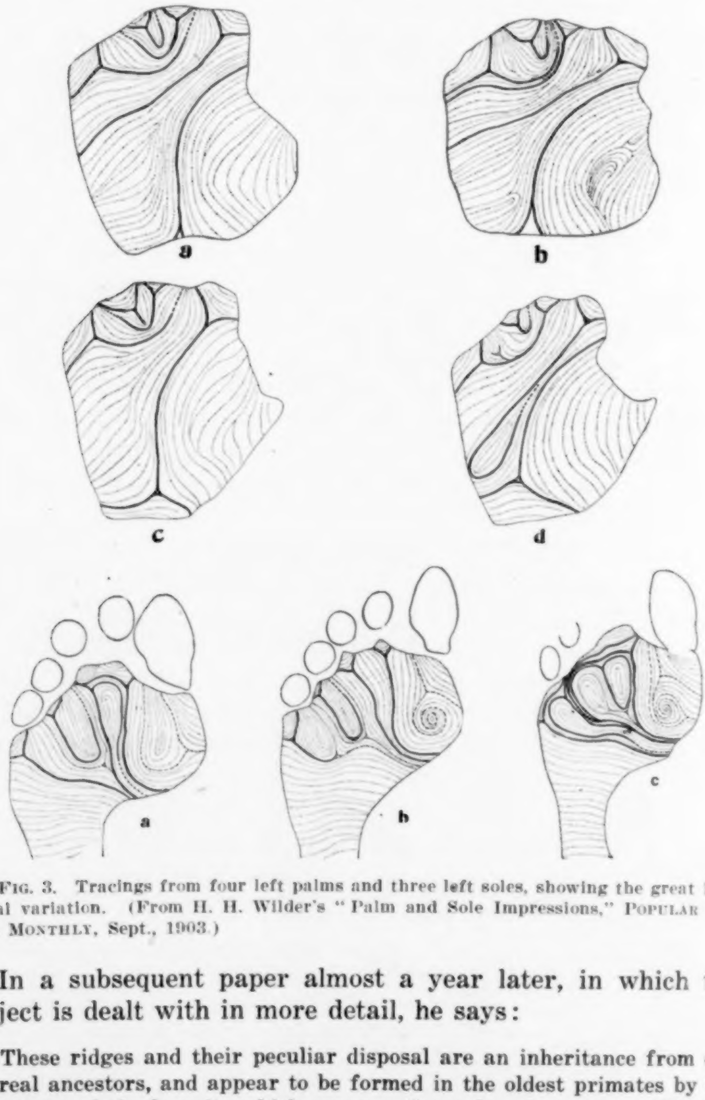

FIG. 3. Tracings from four left palms and three left soles, showing the great individual variation. (From H. H. Wilder's "Palm and Sole Impressions," POPULAR SCIENCE MONTHLY, Sept., 1903.)

In a subsequent paper almost a year later, in which the subject is dealt with in more detail, he says:

These ridges and their peculiar disposal are an inheritance from our arboreal ancestors, and appear to be formed in the oldest primates by the coalescence of single units which arrange themselves in rows.[18] Whether

[17] Wilder, "Scientific Palmistry," POPULAR SCIENCE MONTHLY, November, 1902, pp. 46–47.

[18] Wilder, "Palm and Sole Impressions," POPULAR SCIENCE MONTHLY, Sept., 1903, p. 396. In a footnote Dr. Wilder says "This and other morphological points of which I shall make use in this article are from an unpublished paper on the morphology of the subject by an associate in my department, Miss Inez L. Whipple. At my suggestion Miss Whipple has

or not this phylogenetic or racial stage is now passed through in each human embryo in accordance with the law of biogenesis has not as yet been shown, but it is certain that the ridges are seen fully formed and in their adult condition in a four-months' embryo, and that no change can afterward take place in any detail.

As these surfaces are thus *individually variant* and as their condition is *absolutely permanent through life*, they offer the best criteria for a system of individual records, especially since they may be so easily recorded by means of printed impressions. All these points have been shown by Mr. Galton, who has taken as a basis for his system the markings that cover the balls of the fingers, his "finger tips." The present paper considers the remainder of the ridged surfaces and is thus seen to be *an extension of the Galtonian system to new territory*. Whether ultimately the universal personal records which will surely become necessary in the near future will be based upon a part or the whole of these surfaces is of no real moment, and it is with the idea of being of genuine assistance to Mr. Galton, and without any attempt at rivalry, that I offer in the following pages a method of recording identity by means of palms and soles.[19]

In a subsequent paper, entitled "Palm and Sole Studies," published in *The Biological Bulletin* (Vol. XXX., Feb., 1916, page 135), the subject is introduced as follows:

In the study of the details of the configuration of the friction ridges found covering the surfaces of the human palms and soles there opens up a field of the greatest value to the biologist. *Varying greatly individually;* still following the lines laid down for them in more primitive mammals, yet modified and varied as the result of mechanical causes; showing markedly and with certainty a direct inheritance from the immediate parents as well as from generations more remote; they may be used with great profit by the morphologist, the ethnologist, or the student of genetics, while, as the surest and most positive characters of an individual, they may serve the authorities in the identification of a human body, living or dead.

Undoubtedly the patterns are complicated, and many new conceptions, and the new terminology which expresses them, confront the beginner, as in any new field; but this much once accomplished, there opens up to the investigator an almost endless series of new phenomena the study of which in the few years during which the subject has received special attention has been no more than begun.

Continuing, this paper considers such subjects as "A Primitive Palm Print"; the "Heritability of Friction-skin Characters"; Palm and Sole Markings in both duplicate and fraternal twins, also conjoined twins or those which have never separated completely.

The morphological investigations by Miss Inez L. Whipple

undertaken the comparison of the human conditions of palm and sole with those of the lower primates and other mammals, and has studied also the ontogenetic development of the parts in man and other forms. This work is of the greatest value in the present connection and will be published in full in a short time."

[19] Wilder, "Palm and Sole Impressions," page 396.

(now Mrs. H. H. Wilder), previously referred to, were eventually published (in English) in a foreign scientific publication[20] under the title given below. This paper has proved to be "the fundamental paper on the comparative morphology of the ridge patterns of the palms and soles, and includes the study of the relief of the ridge surfaces in all mammals, and the growth of the ridge surfaces as modified by this. This paper with that of Schlaginhaufen, 1905, are of first importance in the scientific study of human friction ridges."[21] It is certainly most unfortunate that such a fundamental work as this is to the professional fingerprint identifier should be practically unavailable owing to the fact that it was snapped up by a foreign scientific publisher.

A satisfactory digest of this treatise is almost out of the question as every section and paragraph is essential. Space will permit for no more than the table of contents, to show its broad scope and exhaustive treatment; and a few extracts from the text concerning the ridges and apical ridge patterns in man:

THE VENTRAL SURFACE OF THE MAMMALIAN *CHIRIDUM*, WITH SPECIAL REFERENCE TO THE CONDITIONS FOUND IN MAN.

By Miss Inez L. Whipple

With Preface

By Professor Harris Hawthorne Wilder, Ph.D.

Department of Zoology, Smith College, Northampton, Mass.

TABLE OF CONTENTS

[20] *Zeitschrift für Morphologie und Anthropologie*, Stuttgart, Bd. VII., pp. 261–368 (107 pages), 1904.

[21] Wilder, "Bibliography of Friction-skin Configuration," *Biological Bulletin*, Vol. XXX., p. 251.

PART III. Epidermic Ridge Patterns in Prosimians and Primates.
- A. Preliminary classification.
- B. Typical primary patterns.
- C. Modified primary patterns.
- D. Secondary and false patterns.

The process of ridge formation and their distribution with relation to the pads is exhaustively treated in Part II., Sec. *B*. After devoting fourteen pages to the careful examination of ridge formation in the lower mammals, in which the develop-

FIG. 4*a*. FIG. 4*b*.

FIG. 4. Dermatographs from the human heel (left, female) showing in *a*, a normal condition, the unit elements being mostly all fused into ridges, only a few one, two and three unit ridges being present; in *b*, the opposite condition is shown, it being difficult to find a ridge of more than four or five units, the single elements having never fused into ridges. (From H. H. Wilder's collection, Nos. 722 and 754 respectively.)

ment is traced from the simplest epidermic structure, the scale or wart, the most common form of which is a single sweat gland and its pore opening near the middle of the structure (The "island" or "unit ridge" of the identifièr); and the fusion of these elements by one of three observed methods to form the ridge (Fig. 4 *a*, *b*); and demonstrating that the concentric whorl is the primary pattern, Miss Whipple says regarding the ridge development in the higher primates and man:

Although in the higher primates the complete covering of the surface of the chiridium by ridges seemed at first to preclude the possibility of obtaining any evidence of the method of ridge formation, the fact that in

lower forms the transition stages from simple epidermic structures such as warts and rings to fully formed ridges occurs in the regions which are less exposed to pressure, suggested the possibility of finding in the narrow transition area between the ridged region and the skin of the dorsum, especially in embryos, some suggestion as to this process. As the elevation of the ridges is due largely to the rather late development of the stratum corneum, it was difficult to find a stage which was sufficiently advanced to render the ridges distinguishable externally and which would at the same time show the simpler epidermic structures. An advanced human fetus

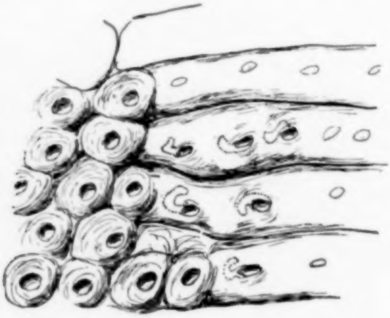

FIG. 5.

proved the most satisfactory for this purpose, and the best results were obtained from the transition region along the sides of the middle phalanges. Fig. 5 shows a camera drawing of a surface preparation of the epidermis of this region. Upon the side of the digit the orifices of the sweat glands are wide and each is surrounded by an elevated rim of the stratum corneum, the whole structure being that of an epidermic wart. These warts appear, however, to be arranged in rows, and the drawing shows a rapid transition from separate warts to ridges, one feature of this transition being the increased length of the coiled ducts of the sweat glands and a lateral compression of their orifices. Except that the transition is a narrow one, the process of ridge formation differs in no particular from that of *Midas lagothrix*. Moreover these warts having been demonstrated in the embryo, it seems safe to conclude that the little separate elevations continuing for a short distance the course of the ridges in the transition regions of the adult skin, usually particularly well seen upon the inner side of the terminal phalanx of the second finger (Fig. 6*a*), are actually primitive warts, examination with a lens demonstrating the opening of a sweat gland in the center of each. In some cases these warts seem to be grouped or fused into rings suggesting the conditions in *Didelphys* and *Lemur;* usually, however, they occur singly. The very frequent occurrence of "islands" in the primate friction-skin also suggests the development of ridges phylogenetically from separate components (Fig. 6*b*).

Three monkey embryos, one an *Alouatta*, the other two Platyrrhine forms (species undetermined), showed along the edge of the friction-skin similar transition stages from warts to ridges.

Concerning the function of the epidermic ridges (Part II.,

Sec. *D*), after extended observations and discussion, the investigator says:

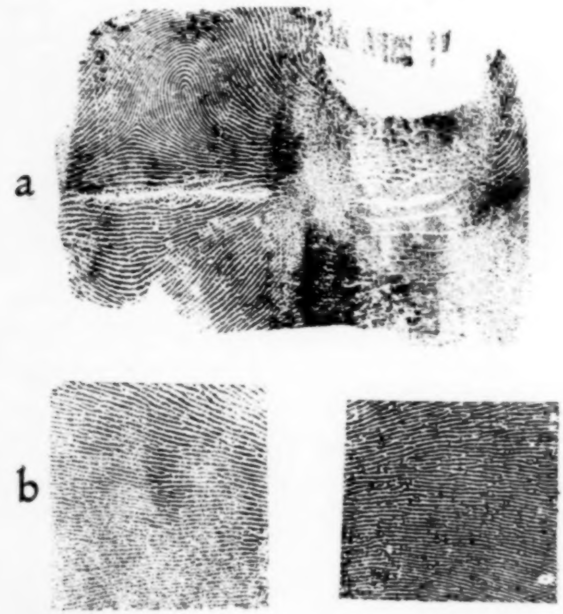

Fig. 6.

The general principles, then, which are involved in the function of ridges are:

1. That the function is primarily to increase resistance between contact surfaces for the purpose of preventing slipping, whether in walking or in prehension.

2. The direction of ridges is at right angles with the force that tends to produce slipping, or to the resultant of such forces when these forces vary in direction.

3. The shape of the pad elevation, the direction of flexion, and the direction of motion are the factors determining the direction of the slipping force, and therefore the direction of the ridges.

Again, " Incidentally the ridges acquire an important tactile function."

In Part III., Sec. *C*, is discussed Modified Primary Patterns; the various types of modification, and their probable cause,

although in doing so it must be borne in mind that a single type of pad modification seldom occurs unaccompanied by others. We may consider these types, however, to be four in number:

1. Failure of divergents, resulting in triradii becoming extra-limital or obliterated. (See Fig. 7*a* and *b*.)

2. Reduction of pads, resulting in degeneration of triradii.

3. Flattening of pads, resulting in a deviation from the concentric arrangement of ridges upon the pad area.

4. Fusion of pads, resulting in the coalescence and in the exclusion of triradii.

a b

FIG. 7. Two apical graphs in which (*a*) one triradius has become extralimital, and the other nearly so; in (*b*) both triradii have become obliterated. In each case an "accessory degeneration triradius" has developed in connection with a loop formation. At the extreme lower corners unit ridge elements may be seen.

Continuing, and referring to group (2), Miss Whipple says:

The modification of patterns which are due to pad reduction are probably the most frequent of all pattern modifications. As reduction has pro-

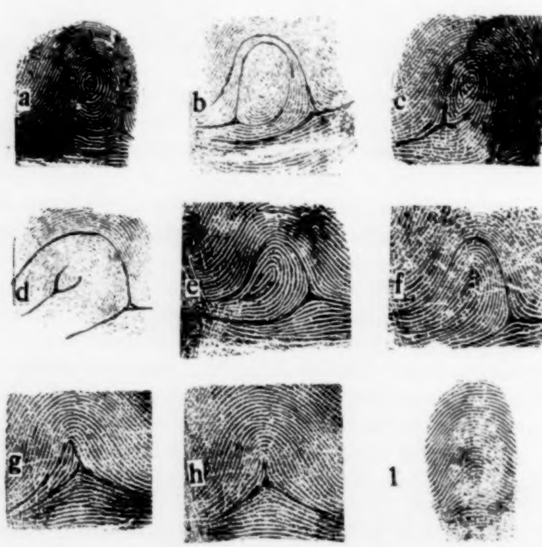

FIG. 8.

ceeded farther in man than in most monkeys (excepting the Anthropoids) *we may select from different individuals of the human species cases which illustrate every step in the process.* The series given in Fig. 8 show how, in the apical pads, beginning with the slipping of one or both of the embracing radiants of one triradius within those of the other, a variation involving at first only a few ridges (*b*), one triradius may approach

nearer and nearer to the center of the pattern (*c*, *d*, *e*), its radiants embracing fewer and fewer concentric ridges until the triradius finally suffers complete degeneration, leaving the pattern known in Galton's terminology as the "loop" (*f*) which has only one triradius, the loop opening in the direction of the divergent of the triradius which has degenerated. Again, by a similar *series of minute variations*, this remaining triradius may approach more nearly to the middle of the pattern, until the loop involves but a single ridge, from which condition it is only a step through Galton's "tented arch" to the "simple arch" in which the last vestige of the second triradius has disappeared. These transition forms in the apical patterns were fully recognized and described by Galton as constituting a slight obstacle to a perfectly systematic classification of fingerprints. . . . It should also be noted that there may occur a simultaneous approach of both triradii to the center of the pattern, the pattern remaining typical in form but reduced in size.

This type of modification is then traced in palms and soles. Under group (3),

Types of pattern modification which are due to a flattening of the pad, a condition which is in some instances correlated with reduction, and in others with extension of the pad area. With the change of pressure upon a pad naturally accompanying such a change of form, very decided modifications in the disposition of ridges occur leading in the direction of the establishment of parallel straight ridges, such as we would expect to find upon a flat surface. The flattened, reduced apical pads both of man and of a few of the monkeys were found to illustrate one very common method of attaining this end. It will be seen from the series shown in Fig. 9 that

Fig. 9.

this line of variation may begin by the displacement of only a few ridges at the center of the pattern, the result being the establishment of a spiral rather than a perfectly concentric pattern. Following this may come a greater and greater amount of variation from the concentric arrangement until a double loop (vortex duplicatus of Purkinje) or even an S-shaped figure is formed. In rare cases more often seen in the apical patterns of the human foot and in the proximal patterns this line of variation has proceeded so far that the pattern has become separated into distinct loops and an accessory degeneration triradius is introduced (see Fig. 7*a* and *b*), that is a triradius not originally present in the typical scheme but formed incidentally in the process of degeneration of the pattern.

Modifications from this same cause occurring in the palms and soles are then considered at considerable length and in great detail.

From this brief biological review it will be seen that any friction-skin impression or dermatograph is really much more than a record of merely external epidermic characteristics, for these features are in turn conditioned upon internal tissue structure of the dermis, the configuration of which is determined and fixed during early embryonic life, and is therefore capable of being associated with but a single individual. Except for a change of size proportional to the growth of the bodily parts, or changes acquired during postembryonic life by external causes such as deep cuts or burns, or from disease of the tissue evidenced by a felon, boil, etc., the configuration remains unchanged through the individual's life.

What then is required to establish an identification; what is the process; how do these biological or anatomical conditions satisfy the requirements?

For guidance, let us consult an authority[22] on the principles of identity evidence:

> . . . In the process of identification of two supposed objects, by a common mark, the force of the inference depends on the *degree of necessariness of association of that mark with a single object.*
>
> For simplicity's sake the evidential circumstance may thus be spoken of as "*a* mark." But in practise it rarely occurs that the evidential mark is a *single* circumstance. The evidencing feature is usually a group of circumstances, which as a whole constitute a feature capable of being associated with a single object. Rarely can one circumstance alone be so inherently peculiar to a single object. It is by adding circumstance to circumstance we obtain a composite feature or mark which as a whole can not be supposed to be associated with more than a single object. The process of constructing an inference of identification thus consists usually in adding together a number of circumstances, each of which by itself might be a feature of many objects, but all of which together can conceivably coexist in a single object only. Each additional circumstance reduces the chances of there being more than one object so associated.

Continuing, he says, in discussing the terms identity, alike, similar, and resemblance:

> We remember to have read in a judgment of the Indian High Courts (unfortunately we can not now give the reference) that the judges considered the case was not proved because the evidence only established *likeness* and not identity. . . . terms such as "exact likeness," "precise similarity" are misleading. For as soon as you have removed all internal difference and resemblance is carried to such a point that perceptible [material] difference ceases, then you have identity. As soon as you begin to analyze resemblance you get something else than it; and when you argue from resemblance, what you use is not the resemblance, but the point of resemblance, and a point of resemblance is clearly an identity.[23]

[22] John H. Wigmore, "Principles of Judicial Proof, General Principle of Identity Evidence."

[23] "Principles of Judicial Proof," John H. Wigmore, Little, Brown & Co., Boston, Mass., 1913, pages 64–67.

Conceiving a fingerprint, or any friction-skin impression, as "*a* mark," what is the "degree of necessariness of association" of that mark with the particular individual whose dermatograph it is?

Dr. Wilder has stated for us the biological truth that the perfection and constancy of an organ are directly proportional to its necessity in the life of the organism; that only useful and important parts retain a certain normal form in the various individuals of a given species, and that as they become of less importance they tend more and more to *vary individually.* Mrs. Wilder has traced this degeneration of mammalian pads and the consequent individual variations in their friction-skin configuration, and has shown us that it has progressed farther in man than in most other mammals, so far, "that we may select from different individuals of the human species cases which illustrate every step in the process." We have seen that *this process is composed of a series of minute variations, constant in the individual,* but progressive and variable among mammals as a whole; and that in the individual the ridges are the result of the coalescence of simple tissue structures and are formed and their configuration fixed in a four-months' embryo.

Since it is inconceivable that these minute dermal structures should themselves be identical or coalesce identically in any two instances, the inevitable conclusion seems to be that the "degree of necessariness of association" of this graphic mark with the individual is *absolute;* that even the possibility of the same or different individuals, having on any two parts of the friction-skin areas identical ridge configurations, is *nil.* Any dermatograph or impression of the friction-skin configuration is therefore a graphic record, by personal contact, of inherent anatomical or dermal characteristics, exclusively individual in the person possessing them, and constant through his life.

But as Professor Wigmore points out, an "evidential mark" usually consists of a group of circumstances, each of which by itself might be a feature of many objects, but all of which together can conceivably coexist in but a single object only; and that the process of constructing an inference of identification consists in "adding circumstance to circumstance."

Analyzed, any friction-skin impression, or more specifically, any *apical dermatograph,* may be thought of as the record of a group of anatomical or dermal circumstances, called by Galton "ridge characteristics." In its gross features it may repre-

sent any of the stages of progressive mammalian variation as shown by Mrs. Wilder and grouped by Sir Edward Henry, on the basis of certain gross likenesses, as whorls, accidentals, twin-loops, lateral-pocket loops, central-pocket loops, ulnar loops, radial loops, tented arches, and the simple arch, the ultimate stage of degeneration. It therefore follows that these "marks" or types of configuration may well be a feature of many objects or fingers (in fact we find them so);[24] so that the repetition of an impression of the same type only raises a suspicion that the two graphs may be from the same digit (or friction-skin area). Aided by a good magnifying glass, a careful comparison of each anatomical circumstance or ridge characteristic, its form and relative position in the configuration, of both dermatographs is therefore necessary. For, if the impressions be *not* from the same digit (or friction-skin area), the record of material anatomical circumstances necessarily associated with the individual in question (*e. g.*, Fig.

[24] For the mathematics of this variability of types the reader is referred to a fifty-seven-page article on the "Association of Finger Prints," by H. Waite, M.A., B.Sc., in *Biometrika* (Vol. X., No. 4, May, 1915), pages 421–478. In addition to the text there are over one hundred statistical tables, enough to satisfy the most ravenous "figure shark." On pages 432–433, Mr. Waite says: "It is convenient at this stage to summarize a few of the most important points which have been brought to light in the foregoing pages. These are: (*a*) A greater divergence of types in the right hand than in the left. (*b*) A clustering of the same type in the hands of an individual. (*c*) The uneven distribution of the various types in the different fingers, especially the almost entire absence of radial loops except in the index. (*d*) The differentiation of types in the two hands, in particular the large excess of whorls in the right hand and of arches in the left thumb. (*e*) Where there is any significant difference in the means, standard deviations and coefficients of variation in the numbers of the ridges in the loops of the two hands those quantities are always greater for the right hand than for the left. (*f*) The relationship between digits of the same name on opposite hands is closer than that between any others which are more widely separated. The relationship between the thumb and any other digit is less close than that of any pair not including the thumb."

"We may thus conclude that the left hand in its distribution of patterns is differentiated from the right and that the individual fingers are associated in a differential way with special types. We know that the right hand is differentiated from the left in use, and it would seem reasonable to suppose, even if we can not account for the adaptation to use, that the fingerprints have been differentiated in accordance with this use differentiation. It may be suggested that the fingerprints, if differentiated in accordance with diversity of use of the several fingers and of each hand, follow a law of differentiated utility, and not as the bones a law of maximum general utility of the finger."

10 *a*) will be absent from the graphs alleged to be his (Fig. 10 *b* and 10 *d*), and it will be found impossible to locate any minute dermal circumstances or characteristics identical to both configurations, the graphs being considered merely alike or similar, according as the resemblance is near or remote.

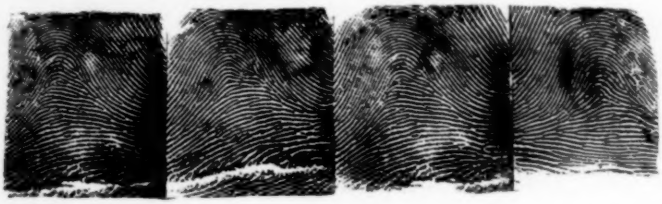

FIG. 10. Four rolled apical dermatographs: *a* is from the right middle finger, *b* from the right forefinger, and *c* an additional graph from the middle finger of the same hand; *d* is from a different individual. Note that even graphs *a* and *c* are not between themselves identical, but only alike; no material differences occurring in their common contact areas, the identity of the individual is unerringly inferred and established by adding dermal circumstance to circumstance.

But, if the dermatographs be from the same digit (or friction-skin area) the record of anatomical circumstances necessarily associated with the individual (Fig. 10 *a*) will be found in the common contact area of the graph truly his (Fig. 10 *c*). It will, therefore, be possible by comparing both configurations to add dermal circumstance to circumstance and to carry the resemblance to such a point that material difference ceases in the common contact areas, and from them to a common cause, the individual digit; for all the minute dermal circumstances taken together (in these two graphs nearly 100 pairs) can conceivably coexist in but a single finger; and the finger conceivably belong to but a single individual.

THE MAN OF SCIENCE AFTER THE WAR

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PROBABLY nothing less than a war such as this could have shaken the British race out of its comfortable mental inertia in regard to all things scientific. The English generally had no interest in science, even though it had conferred on them such extremely convenient adaptations of pure science to the needs of everyday life as the telegraph, the telephone, the electric light and the motor car. Science, however, does seem to be coming into its own. For the first time in the history of the British Empire, this Cinderella amongst the things of the mind is being taken from the kitchen and led to her place on the throne.

Men who have been speaking of war as "applied chemistry" are now considering that it would be a good thing if the treasures of science, so horribly misapplied, could be utilized in the future systematically, openly, advisedly for the beneficent aims of peace. For modern life is begun, continued and ended in science; it is applied science from morning to night, from birth to the grave.

Men are asking themselves: If it was in the power of science to make war so frightful, is it not within her essentially beneficent capabilities to make the coming day of peace fuller, richer and more glorious than ever day in the past has been?

It can not be denied that science as science has only very recently been allowed to have an independent existence in the British, national, intellectual system. The time is within the memory of some of us when the attempt to introduce laboratory teaching into the University of Oxford was met with furious resistance; and when at length studies in practical chemistry were instituted, they were alluded to as "stinks."

History was repeating itself, for Leo Africanus, writing in the early part of the sixteenth century, thus described the chemical society of the learned Arabians at Fez, "there is a most stupid set of men who contaminate themselves with sulphur and other horrible stinks." The attitude of England's premier university was in precisely the same spirit as that of the ex-priest who, on demanding the execution of Lavoiser,

declared that the Republic had no need of chemists. This was in 1794; but fifty years later Oxford made it very clear that she too and all that she stood for in English life had no need of chemists or of any other kind of scientist. This was the traditional, mental attitude of educated Englishmen right up to the mid-Victorian era. The English gentleman knew no science, did not want to know any, and honestly thought that his country did not need to know any. We are all too apt to imagine that what we don't happen to care about is not worth while other people's caring about. The English gentleman certainly seemed to get on very well without science, as his ancestors had done before him; and where were there any gentlemen so perfect as those of English birth? The Englishman spoke, like one of the characters in "Trilby," contemptuously of all foreigners as "damned." He had his ancestral seat and his large rent roll, and his scores of servants, so that he never wanted for daily food, nor needed to soil his hands from one year's end to the other. If he did want a profession for a younger son, were not the Church, the Navy, the Army, the Diplomatic or Civil services all open to him? Everything else, including science, might be left to beastly, eccentric, long-haired "foreigners." In the Navy and Army, whatever else he was, he was brave; but he left any science which those services required to those far beneath him, to those specially paid to bother about "beastly technical details." As regards the practice of medicine, an applied science, he held exactly the same view as the ancient Roman who regarded that occupation quite unworthy of a gentleman. The author remembers well when, in the early nineties, he once filled up a form under the heading "Profession" with the word "physiologist," his father exclaiming, "But that's not a profession!" He was perfectly right from the mid-Victorian standpoint; it was not a profession in the sense that the Church, Fighting or the Law were professions. Where were the ancient privileges, social recognition, pensions or fees for physiologists? There was a day when it was perfectly true that the world had no need of physiologists. I was told the truth when I was once informed that as far as my occupation was concerned with social recognition, I might just as well have been a hangman.

Science had not yet come into her own.

A very great deal of all this has been changed with the inevitable onward march of the army of seekers after truth. Science became less an affair for amateurs and more the concern of serious men. The founding of University College, London,

the instituting of degrees in pure science—B.Sc. and D.Sc.—by the University of London, did a great deal to foster the study of pure science in England and give it academic status. The uprising of the school of biology at Cambridge under Foster and F. M. Balfour was all in the same direction; but in some nostrils at Oxford science still stinks, and—it is no profession.

When one says that the man of science is necessary to the national life, one generally thinks how science underlies our great trades and chemical manufactures and all the activities of our complicated social system, railways, steamships, wireless telegraphy, gunnery, aviation and the untold wonders of to-morrow. But the man of science is as necessary to national welfare in an infinitude of less conspicuous and more familiar ways. There is scientific farming and there is scientific marketing; there is a science of dietetics as surely as there is a science of agriculture.

Science is looking into everything, focusing her light upon everything. When the light of nature fails, then science steps in; she illuminates and directs our paths; she allures "to brighter worlds" and leads the way.

Science, therefore, in the national interests must be encouraged. But there is no such thing as encouraging science in the abstract; it is the men of science, themselves, who have to be encouraged; and encouragement means, to put it brutally, being paid salaries on which they can think and work without financial worry. This is put brutally, but it is not so brutal as the being presented with bills to be paid out of an inadequate income.

The man of science is intended to research, every one will admit; but in whose time and with whose money? We may as well be frank about it. If he is a professor at one of the universities, he probably has all his day filled up with his teaching and administrative duties. In such a day, what time is there for research? He has to teach for a living; his time is not his own, but the governors' of the university. Suppose for a moment that all his day is not occupied with university duties, is it his *duty* to research in the university's time? Most people would reply that it certainly is. But not every professor is appointed with explicit instructions to do research when he is not teaching. He may not be capable of doing any research at all; may never have done any; he may not have been appointed because he could do research, but for some quite other reason. It is a nice point: unless it is definitely understood that the professor is expected to do research, he is using the

university's time for non-university pursuits. For the research in question may not benefit the university at all; it may, conceivably, benefit some other institution, or, inconceivably, the professor himself. But whatever or whoever is benefited, almost all research in universities is done in university time and with university money, so that we shall suppose that there is tacit permission given by the university authorities for such work. It is, however, perfectly possible that the amount of time available when the university teaching duties are done, and the time in the home circle passed, is quite insufficient for the long stretches of work which almost every research demands. You can not follow out any line of work in odd periods of isolated ten minutes, the worker must have hours of uninterrupted work at a stretch. It is precisely this that the teaching professor can not have; either his teaching or his research must suffer.

The only solution is for the universities to acknowledge that they are institutions quite as much for the prosecution of research as for the teaching of young people either the foundations or the heights of science. It should be made quite clear that the members of the staff are fulfilling their university duties quite as faithfully when they research as when they lecture, and that their salaries will not depend on the number of teaching hours per week, but on the cost of living in the particular city in which the university happens to be. Probably the only satisfactory solution of the teaching *versus* research problem is for the universities to recognize teaching professors and research professors, teaching assistants and research assistants. It should, in fact, be acknowledged that it will be regarded as a credit to the university if certain of its professors research rather than teach, as was the case with the late Lord Kelvin. Lord Kelvin's forte was not teaching the elements of physics to junior students who knew no mathematics; yet this was the daily duty actually set before the greatest physicist since Newton. Had Lord Kelvin not shed such great luster on his alma mater by the brilliance of his reputation as an original worker, he would have come within a very little of being put down as a failure. He researched, however, in the university's time; but as far as I know there was nothing in his Lordship's commission about research as a part of his duties.

Both the teaching members and the researching members of the staff should receive such salaries as would make them independent of worry regarding the financial *modus vivendi.* The teaching professor should not have to research in order to

convince himself that only by so doing is he carrying out his entire duty; the researching professor ought not to have to teach in order to obtain a salary to enable him to live.

The importance of the researches done at the Rockefeller Institute of Experimental Medicine is a proof of the great value to science of the endowment of an institution whose staff is not burdened by teaching as the only means to a livelihood. An eccentric Scottish professor once said: "The university would be a fine place if it were not for the students!"

When we touch the subject of salaries, we come to a question likely to evolve more heat than light. Broadly put, it may be said that professors of science subjects are not paid salaries commensurate with their highly specialized attainments, nor such as enable them to live in the style expected of other dwellers on the same social stratum. It is of course quite foreign to the subject to say that they are not paid as highly as all sorts of persons whose mental attainments are inferior. There is no general scheme of paying salaries according to the degree of attainments salaries are paid on the basis of the scarcity in the "market" of the kind of person to receive them. Now since there is no market for professors in the same sense that there is for clerks or day laborers, and since there is always a relatively large number of trained men willing to work for a small salary because they know very well that they can not get a large one, professors are compelled to take quietly what is given them and to ask no questions. This is no new grievance; the smallness of professors' salaries has long been a standing joke in the comic papers. It is indicative of the small regard in which men of science are held. Hitherto their researches have been seized on and commercialized for the benefit of other and more worldly wise individuals. It is this sort of thing which will be changed after the war. The man of science must be recognized as the most important person in the post-bellum community, a person without whom the capitalist would have no discoveries to commercialize.

We should have a Minister of Science, whose duties would be amongst others to see that scientific men were encouraged, subsidized, promoted, rewarded and pensioned. For why should state recognition, encouragement, promotion and rewarding be reserved for sailors, soldiers, diplomatists and lawyers? Why should it be so entirely correct to be paid for legal opinion, and such "bad form" to be remunerated for scientific advice? Because, it may be replied, the law is an ancient, respectable profession, and science is so recent, it is not a profession at all.

This medieval state of affairs can not go on indefinitely; it was all very well for the day when there was no science to foster, but it is out of place in an age which lights its cities by the invisible, speaks to the antipodes without wires, flies in high heaven like the eagle, and descends to the abyss like a sea monster. Much that now falls under the supervision of the Home Secretary could be transferred to the Science Minister. The first concern of the science office would be the place of science in the schools of the Empire, the still burning question of the rival claims of science and the classics. It ought to be perfectly possible to instruct boys in as much of Greek and Latin as would make them know the origin of the words in English derived from those languages, without necessarily making the boys read entire Greek and Latin authors in the original. Through our national physiological momentum we have been educating boys as though they were all going to be teachers of the classics; we have continued on the same educational lines as those laid down by Linacre and Erasmus when America had just been discovered and printing just invented.

The Science Office will see to it that science receives official recognition in all entrance examinations whatsoever, and is not handicapped by receiving fewer marks than the classics or any other subject.

Science must have its place on every curriculum, not on sufferance or by-your-leave, but by right of its inherent dignity and in virtue of its essential usefulness. Why is a knowledge of science so useful to the modern community? Because, apart altogether from the way in which it makes for technical efficiency, it is a means second to none for the training of the intellectual powers. It trains us in accuracy of observation, in the power of drawing trustworthy conclusions, in the habits of precise, critical thinking—and these are not small things.

Science, the true, is the patient, loving interpretation of the world we live in, it is a striving to attain not merely to an understanding of the laws whereby the world is governed, but to the enjoyment of the order and beauty which are everywhere revealed.

Amongst the many unspeakably sad things which this war has brought about, the prostitution of science and the destruction of things beautiful are not the least lamentable, for

> Outraged science shudders that her glorious treasures
> Should be so corrupted by the sons of men;
> Beauty's gentle spirit grieves as it grieved never
> For those scenes of Beauty that can not come again!

FACTORS IN ACHIEVEMENT

By Dr. P. G. NUTTING

IN the increase and diffusion of organized knowledge and in its application to special problems for the national welfare, the selection and training of individuals of course plays an important part. The capacity for unusual achievements is in part born in the individual and in part the result of his environment, (1) inherited tendencies and (2) education in a broad sense. The individual favored in both respects with capacity for achievement may or may not accomplish great results according to the (3) incentives to activity he may possess or develop and according to certain (4) fortuitous factors, ideas and impulses coming apparently from nowhere, which may influence his choice of activities.

From the point of view of practical work, the capacity for success depends almost entirely upon but two factors—fertility of mind to originate ideas and judgment to select from these the most vital and effective. With an energetic use of both, worthy achievement is assured, the importance of activity and practical experience lying in the fact that its effects are strongly cumulative, each bit of experience enhancing ability to achieve more. Hence, the considerable effect on national achievement of such an apparently trivial factor as climate. In a well-organized democracy, each individual should have equal opportunity to acquire (1) knowledge through study, assimilation and deduction of fundamental principles, (2) skill through application of these principles to practical problems and (3) incentives to productive effort. These are the essential qualifications of the expert and since, in any highly efficient democracy, all problems of moment must be handled by experts, the fundamental problem is the application of organized knowledge to bring about such a condition, the "rule of common sense."

1. *Inherited Tendencies.*—With equal opportunity to acquire knowledge and skill, the proper choice of vocation depends chiefly upon inherited traits. Usually but a few traits are dominant and the proper vocation is not difficult to determine within rather narrow limits. An occasional individual possesses a wide variety of overlapping tendencies and is

capable of achievement in a variety of callings. Many others exhibit no dominant mental characteristics, being fitted only for work in the less skilled crafts and trades.

As stated above, the ability to grasp and correlate ideas is a proper measure of mental power. Now some classes of ideas are better and preferably correlated than others and this preference is a necessary and sufficient criterion of natural fitness. The musician is keen in associating auditory impressions, the mathematician in abstract logic, the physicist and chemist in physical and chemical laws, and so on. This choice of class or classes of ideas to be correlated is instinctive in that it is born, not made, and characteristic in that it is not precisely the same in any two individuals. It varies with age, but at a given age (say twenty) it is a safe basis of judgment. The somewhat detailed classification below will at least illustrate the application of this principle.

The *creative* type of mind is probably the least complex. The scientist, artist, engineer and professional man must be capable of a high degree of abstraction, hence must be individualistic rather than gregarious in his tastes. The ideas which dwell in the mind of the writer and which he instinctively ponders and correlates are stories and plots. The artist is keen on form and color—visual impressions—the musician on sounds. The ideas which grip the mind of the scientist are abstract fundamental relations between cause and effect. The engineer and professional man in general ponder concrete problems and applications of fundamental principles. It is even possible to differentiate between the lawyer, the physician, the agriculturalist, the mechanical engineer, the banker and other types of engineer in early youth by means of the tastes which they exhibit for different classes of problems.

On the other hand, the *administrative* types, be they commercial, political, protective or pedagogical, are gregarious rather than individualistic. Their tastes do not run to abstract ideas so much as to personal relations. They are keen to make and keep friends, are good "mixers" and entertainers, fond of activity and are experts on behavior. The commercial type of individual instinctively suppresses his own feelings and wishes to please others—and make a sale. The executive type is keen to anticipate conditions and relations between others. The good teacher is fond of the society of those less well informed and keen on making his own ideas plain to others. He must of course have a goodly supply of certain classes of ideas and be a good practical psychologist.

In addition to determining fitness for a particular life work, inherited traits have a great deal to do with eminence in a given calling, although perhaps not dominant factors. Fertility of mind, ease of assimilation of new ideas, the tendency to activity and general smoothness and precision of mental operation are largely born in the individual rather than acquired and have a great deal to do with success in life. All are usually in evidence in early youth, if at all. None are of consequence, of course, unless coupled with a proper education, mental, physical and moral, and with proper incentives to activity. And all these characteristics, whether inherited or acquired, are of little avail without an intimate knowledge of the complex conditions of modern life obtained by daily contact with them.

2. *Acquired Knowledge.*—To be a vital factor in achievement, education should provide not only a book knowledge of fundamental principles, but skill in applying these principles. One extreme of education is represented by the individual with purely academic training, resulting in mere breadth and depth of impotent knowledge, possessing neither the ability nor the incentive to use it. At the other extreme is the self-made individual with a thorough first-hand knowledge of certain classes of problems and of certain basic principles applicable to them. There can be no question as to which is of greater value to the nation, but both are far from ideal.

The best education consists in a steady, life-long assimilation of ideas coupled with a deduction of principles. The acquisition of learning should go hand in hand with an application of that learning to special problems. The natural method is (1) the analysis of a problem, (2) the application of known principles followed by (3) the deduction of new principles or extensions of the old. The laboratory method used in teaching most sciences in this country is a close approximation to this method. The older education, aiming at training in interpretation and expression, was good as far as it went in a certain field of achievement, but the field was narrow. The best education should provide the maximum knowledge, skill and incentive possible to the individual in his chosen field of endeavor. Its aim is to produce experts—experts in the application of fundamental principles. Its methods are to teach those principles through their application. And the most important part of the education is the inculcation of the principle of the method itself. Agassiz taught the gold expert by giving him a turtle to study! He learned the method and this knowledge with the fixed purpose of becoming an expert and doubtless con-

siderable natural ability were the essential factors in his success.

Our students waste much valuable time and learn wrong methods of study because our system leads them to work by the day rather than by the job. The installation of a piecework system would require better teachers and probably more of them, but would result in incalculable benefit to the nation and a great saving of time to the student. Students who attend college chiefly for the social or athletic advantages it offers should not be tolerated. Teachers should be thoroughly versed in the basic principles of the branch taught and in the proper methods of acquiring knowledge. Whether the subject taught be mathematics, language or biology the first aim should be to see that the student gains a real command of the subject. Proper teaching will result in better teachers and finally in better taught students.

3. *Incentives to Activity.*—Under normal conditions the average individual operates on low gear, seldom rising even to second. Any one who habitually operates on high and is reasonably endowed with intelligence and common sense is reasonably certain of great achievement. Our present problem is to outline the incentives tending to induce us to put forth our best efforts. If we but put forth our best efforts, our future is assured, either as individuals or as a nation.

Take the most talented and energetic scientist and isolate him, say on a desert island. Give him a library and a laboratory, but no companions and in a few months or years he will run dry of ideas and become barren. We are so constituted that continued productiveness is conditional upon intercourse with our colleagues. In many respects our activities are like the individual cells in our muscles—we function properly only in contact and cooperation with our fellows. The problem of incentives is therefore complex and primarily one of interrelations.

In any great achievement two factors are essential, a motive (or several motives) for doing it coupled with capacity to accomplish the desired results. In each motive may be recognized a more or less continuous incentive and an idea or impulse coming apparently from nowhere (vide infra). Every one has his favorite category of incentives. There are at least six classes of these and any scheme of classification is about as good as any other. From the purely *mechanical* point of view one is acted upon by various forces due to conditions existing among our surroundings. Life is a series of actions and re-

actions resulting from unbalanced forces. Action is greater or less according to inertia, plasticity and elasticity. Purely *physiological* considerations lead one to think of cell charge and discharge as the basis of activity. In health, rest and food lead to charged brain cells ready to react to a nerve stimulus. Impurities tend to break down these nerve cells in chains or groups, giving rise to definite ideas. Emotions tend to polarize the charged brain cells so that a more copious discharge may result.

From the standpoint of *mental* engineering our activities are a series of problems, many of these are nearly identical with problems solved many times previously and are largely taken care of by habit, while others are original and require working out. Ideas come to us and we follow them up through a logical chain to a definite end point. Unable to solve a problem, we take it up again and again, contact with the problem and with the work being a powerful incentive to continue. Our interest in any problem is in proportion to the possibilities we see in it and in lesser degree to the headway we are able to make with it.

Incentives are in better alignment from the *sociological* point of view. Our strongest incentives are the winning and retaining the respect and esteem of those with whom we are in contact. We are impelled (by instinct) to fill our place in the social organization much as a cell fills its place in a nerve or muscle. Those who care little or nothing for the esteem of their fellows are criminals and outlaws. To enhance the esteem of our fellows we contract to deliver certain results and, knowing the price of failure, the filling of our contract is a powerful incentive. The attainment of the social freedom usually connected with abundance of money is a powerful incentive to some. Emulation influences many. The strongest of all incentives are self-preservation and the stern necessity of living up to a standard, the standard of our fellows or one set by ourselves perhaps.

On an ethical or *moral* basis, our incentives are those of principle and duty. Our one fundamental duty is to be our best selves and live up to our possibilities. The hope of reward in the form of pleasure or happiness or the fear of discomfort are strong incentives in the less highly organized mind. To others, the satisfaction resulting from duty well performed is a sufficient incentive for any labor in achievement, even to the sacrifice of life itself.

From the *psychological* viewpoint, incentives plus impulses

are the stimuli to mental exertion. A series of more or less related impulses leaves in our minds that which is common to all of them in the form of a more or less permanent incentive. Upon that incentive depends the nature and extent of our reaction to fresh ideas as they come, our wish or will to develop the idea toward certain objectives or to suppress it into desuetude. We develop methods of inviting and forcing ideas of our choice, repeated reactions of similar nature lead to the formation of habits and of character. Experience teaches that the giving way to impulses of a certain nature (*e. g.*, that of doing our best) is always approved by our judgment and an incentive to continue the same behavior is formed. In other words, incentives determine the volitional choice of conduct. The volitional factor ranges from almost nothing in the case of the instinctive incentives to practically the whole of those incentives which are matters of judgment and principle. When under emotional stress we react much more readily and strongly along the lines of our dominant incentives.

Apparently, a strong line of good incentives can not be created; it must be built up by careful and persistent effort and that effort must itself be the result of incentive. With the adolescent, the aims and examples of friends and acquaintances and the teaching of parents are powerful formative factors. Youths pattern their lives after those they admire almost instinctively with little reason or judgment.

A powerful factor in achievement is the inhibition of such contra-incentives as habit. In a sense, men are like snakes and other reptiles—in order to make the best progress it is essential that they periodically shed a skin or shell of habit. A simple and natural method of doing this is to move into new surroundings and form new acquaintances from among a set of entire strangers. The formation of a new set of habits automatically dispenses with the old set. Fresh incentives arise and are given free play while old incentives are rejuvenated. By this means, achievement is frequently enhanced many fold.

The practical means of enhancing our incentives are very limited. We may stimulate ourselves to some extent by moving into new surroundings. We may contract with others or with ourselves to deliver certain results. No inconsiderable stimulus comes at times from merely getting started, mere contact with the work itself engendering interest and application. After the dominant point of view has once been located among the

six classes above outlined, best progress may be made by confining attention to that one line of appeal. If the boy tends to think in terms of moral principle appeal to his morals. If he is gregarious, teach him through his friends, and so on.

The strongest of all incentives—self-preservation, the struggle for existence, competitive rivalry and the instinct to attain and retain the respect of our fellows—lie nearly or quite beyond our control. But it is frequently quite possible to imagine these as existing in greater measure than is actually the case and so spur ourselves from the field of fatuous content into increased activity and achievement. The story is told of a hen that was unable of herself to fly over a fence, but by inducing a dog to chase her was able to clear the fence and to spare! The incentive of the hen roost was insufficient, but that of self-preservation was ample for the task to be accomplished.

4. *Fortuitous Factors in Achievement.*—Among the contributory factors leading up to any great event in the world's history may always be found ideas and impulses coming to certain individuals apparently from nowhere, vital in initiating whole series of events. Cæsar hesitated at the Rubicon, but finally obeyed the impulse to cross and end the Roman republic. Many a great war started from an impulse to conquer the world, coming to some individual ruler. Had Lincoln not obeyed the impulse to take on Douglas in debate, it is quite probable he would never have been president and one of the dominant characters in history. Any man of great achievement can recall many instances of fruitful lines of activity originating in some impulse. Since such impulses are frequently very important factors in achievement, it is well to scrutinize them with care, attempting to discover some general pattern, some laws of appearance and the best means of utilization.

Countless impulses come to every one during his whole life, dozens during each waking hour in fact. Of these, a considerable portion may be traced directly to suggestions made by our associates, others arise from our personal needs and desires. Many, however, simply flash into consciousness much as do words, faces or the solutions of problems. Impulses involving action are either inhibited or acted upon and our whole lives may hinge upon the result of the decision. Such impulses must be common to the whole animal world that is capable of voluntary action. They range in quality from mere reactions to abstract ideas and in number from a few per day to many per

minute. The frequency of occurrence of high-grade abstract ideas and impulses is a measure of mentality. That frequency is higher the more intimate our association with our fellows. During periods of isolation, in fact, we quickly run nearly dry of both ideas and impulses. The advanced civilization attained by the Greeks may be attributed in large measure to these gregarious habits of association and discussion, resulting in a stimulation of the production of ideas and impulses.

Every impulse involves a decision to do or not to do a certain thing or to do this rather than that. As we habitually lean toward decisions of a certain nature, our whole lives are affected. The one who is prone to follow up impulses involving activities just within the limits of his powers will make the most rapid progress, come nearest to living up to his possibilities and make the most of his life and endowments. This is the whole secret of useful activity, of having the correct philosophy of life to make the proper decisions between impulses of trained judgment and great achievements in general. A good teacher is one who begets impulses in his students to undertake difficult tasks and to do their best in accomplishing them. Inherited tendencies to have original ideas and impulses and to undertake carrying out the most telling of these are our most valuable heritages.

Of the influences at our command which breed valuable ideas and impulses, not much is known. Helmholtz stated that the solutions of difficult problems most frequently came to him in walking up a certain hill on a sunny morning. To most of us, however, such ideas and impulses doubtless come most frequently during animated discussions with our colleagues. Alcoholic beverages are notoriously inhibitive in their action. They may appear at the time to be effective, but cold judgment shows that this conclusion is illusory. Narcotics undoubtedly have a temporary stimulating effect on originality, but with reverse after effects. The incentives to activity discussed above are, almost without exception, effective in generating fresh ideas and impulses, productive effort and originality being developed together. Our judgment of fresh impulses in selecting those worthy of further effort is partly instinctive, largely the result of a philosophy of life (of what is most worth while) developed during adolescence and partly the result of education and experience. Happy is he who instinctively takes a broad and far-sighted view of what is best worth while and who strikes while the iron is hot.

Summary.—The individual of great achievements is one with the thorough grasp of fundamental principles of the scientist, the ability to analyze and solve difficult concrete problems of the engineer or the originality to conceive and the skill to create the ideal or approximations to the ideal of the artist. He requires a heritage of originality and keen vision, unerring judgment obtained by proper education and experience, tireless enthusiasm and energy to accomplish desirable ends and finally a continual flow of worth-while ideas and impulses. Any one with suitable inherited qualities, striving for a maximum of achievement and usefulness to the nation, may properly devote himself to the acquisition of sound judgment and of ample incentive to activity. Thus are experts made and the leading nation of the future will be a nation of experts occupied in furthering the interests of that nation.

RELIGION AND SOCIAL CONTROL

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RELIGION has fallen upon evil days, and civilization upon still worse ones. To superficial scientific thinking there may seem to be no connection between the state of religion and the present disturbed state of the world. For have we not been assured, very often in the name of science, that all religions are false and harmful to social progress? Self-styled "rationalists" have repeatedly asserted that science can find nothing in religious beliefs except superstition, error, or "the will-to-power" on the part of some privileged class. On the other hand, representatives of religion have not infrequently proclaimed it to be outside of the field of science, and have sometimes resented its scientific study almost as if it were a species of "sacrilege." Both attitudes have made difficult a truly rational, scientific and objective understanding of religion as a social phenomenon.

But the question of religion will not "down," either through scientific or religious obscurantism. More and more men are beginning to ask the meaning of religion in human life. Can civilized society, they ask, afford to dispense with religion? Or is religion something which enters necessarily into the warp and woof of civilization? In the reconstruction of our civilization which we now face it is time that scientific thinkers have some definite opinions to offer in answer to such questions. For if religion is a vital element in civilization, nothing could be more foolish and short-sighted than ignorance and indifference regarding its forms and functions.

Real science, however, in seeking to understand religion as a social fact rather than to pass upon the validity of any of its particular doctrines, is far from taking a hostile or an indifferent attitude toward religion. The most unprejudiced anthropologists and sociologists would probably agree with Professor Hobhouse, one of the most careful social thinkers of our time, when he says:

> The element of religion is common to all forms of society . . . as an element involved in the social consciousness itself and as a factor strengthening its hold upon the minds of men.[1]

But if this is so, and if science exists to serve humanity, then again it is time that the scientific world realizes the part which

[1] "Social Evolution and Political Theory," p. 128.

religion plays in social life, particularly as a means of social control.

But what is civilization, and what is religion, and why are they vitally related? Civilization, as we have seen,[2] is a complex of acquired habits. It is not innate in man, but each generation has to acquire the ever-increasing mass of habits and traditions which make it up. But these habits and traditions can not be passed on successfully from generation to generation in human society without strong social sanctions or adequate means of social control; for many of them call upon the individual to restrain his animal impulses and even to sacrifice himself for the good of his group. The social values which these habits and traditions represent accordingly, especially those which involve sacrifice of individual interests for group interests, have to be brought to the consciousness of the individual in the intensest way; or else proper social adjustments and habits will not result. Hence develops the whole machinery of social control—government and law on the side of the external acts of the individual, religion and morality on the side of the internal motives and beliefs. The most ancient of these means of social control is probably religion. As soon as the habits of any primitive group were reflected upon in connection with the welfare of the group they became inevitably associated with the elements of "luck," of good fortune or bad fortune, of safety and danger, to the group—in brief, with the whole mysterious, wonder-working powers of nature. Thus superhuman sanctions became attached to those habits of action which were found to be safe and to conduce to group welfare. They became, in other words, the "mores" of the group; and the "mores" thus imbedded in religious sanctions became all-powerful. Out of them were developed all the other agencies of social control. It is for this reason that we find primitive science and art, as well as primitive government, law, morality, and education all associated with religion—often, indeed, indistinguishable from it. Social control was thus primitively a religious control. And through all the subsequent centuries religion has been the core of social control, because it has been at the heart of the standards, the values, the "mores," of every civilization. We know, indeed, of no civilization which long endured that did not have a religious setting for its mores; nor of any which long endured after this setting was dissolved. When the religious sanction for the mores crumbles and disintegrates, the mores lose their vital hold upon the individual, especially those which demand self-restraint and self-sacrifice.

[2] THE SCIENTIFIC MONTHLY, November, 1917, p. 439.

and the civilization of which they are a part itself crumbles and disintegrates. The reason why this happens will become more evident as we proceed.

What, then, is religion, and why does it have this peculiar effect upon the mores? Fundamentally it is man's valuation, in an ethical sense, of his world, especially of that unknown part which is not covered by his work-a-day experience. It is a projection of man's social and personal values into the universe as a whole. Man must have a way of meeting every crisis in life; and life is ringed about with crises. He must necessarily make adjustments both toward the known and toward the unknown. He must of necessity have beliefs in regard to all of the adjustments which he has to make; for from beliefs and values come adjustments and attitudes. Some sort of valuing attitude he must have, therefore, toward the "*X*" realm of experience. Now religion is just this valuing attitude toward the unknown powers which are behind the phenomena of the universe and the desire to come into right relationships with those unknown powers. It does not particularly matter what formal definition of religion we may accept. We may subscribe to Professor Frazer's definition that "religion is a propitiation or conciliation of powers superior to man which are believed to control the course of nature and of human life";[3] or we may accept a more recent definition that "religion is man's attitude toward the universe regarded as a social and ethical force."[4] The essential thing is to see that religion arises as soon as man tries to take a valuing attitude toward his universe, no matter how small and mean that universe may appear to him. Some sort of religious attitude is necessary as long as men think and feel with reference to their world as a whole, and do not, ostrich-like, refuse to confront the reality in which they live and move and have their being.

Now in projecting social and personal values into the universe religion universalizes and makes absolute those values. Accordingly, just as the rationalizing processes of the intellect give man a world of universal ideas, so the religious processes give man a world of universal values. The religious processes are, indeed, nothing but the rationalizing processes at work upon man's instincts and emotions rather than upon his percepts. Man is the only religious animal simply because through his powers of abstraction and reasoning he alone is able to universalize his values. What science does for ideas, religion, then, does for the feelings; it universalizes them, and in uni-

[3] "The Golden Bough," second ed., Vol. I., p. 63.

[4] Barton, "The Religions of the World," p. 3.

versalizing them, it brings them into harmony with the whole of reality. It thus harmonizes man on the side of will and emotion with his world. Hence the noticeable individual effects of religion. It is the foe of pessimism and despair. It encourages hope and gives confidence in the battle of life to the savage as well as to the civilized man. It does this because it braces vital feeling; and it braces vital feeling, psychology tells us, because it is an adaptive process in which all the lower centers of life are brought to reinforce the higher centers. The universalization of values means, in other words—in psycho-physical terms—that the lower nerve centers pour their energies into the higher nerve centers, thus harmonizing and bringing to a maximum of vital efficiency life on its inner side. It is for this reason that religion taps new levels of energy, gives strength and confidence in oneself and in one's world, and often enables men to perform deeds far beyond what are commonly regarded as normal human powers.[5]

Now this fact that religion releases fully the energies of the individual in periods of crisis, braces his vital feeling, and helps him to face the issues of life and death with confidence in himself and in his world, is of course of the greatest social significance. For a social life without crises which demand self-effacement and self-sacrifice on the part of the individual is unknown and probably impossible. The dream which the hedonistic philosophers of the nineteenth century had of a "pleasure economy," a social order in which there would be no need of sacrifice on the part of the individual, because the difficulties and evils of life would be all overcome, has for the present, at any rate, been rudely shattered. The World War has shown that there is as much need of faith, loyalty, self-sacrifice, and self-devotion in the world as ever. And in the increasing complexity of human social life in the future there will probably be as much call for heroism, self-devotion, and self-sacrifice as in previous generations. Men will always need, in other words, for efficient, worth-while human living full command of their adaptive powers; and highest among these standing side by side as it were, the one intellectual and the other dominantly emotional, yet often in these latter days made strangely to antagonize each other, are reason and religion. However, the particular problem with which we wish to concern ourselves is not this energizing of life through religious beliefs and emotions, but rather the preservation of social order.

Religion has been from the first a powerful means of social

[5] For the psychological elaboration of these facts the classical work is, of course, James's "Varieties of Religious Experience."

control, that is, of the group controlling the life of the individual for the good of the larger life of the group. Psychologically it functions, as we have seen, to universalize values and make them absolute, so that they come into the consciousness of the individual in the intensest way. But the values thus universalized and made absolute are almost always those which come to the individual through the tradition of his group. They are values, in other words, which have been built up through the common life and transmitted from generation to generation because they have to do with the life of the group. They are social values. Again, it is the human world about him to which the individual has to adapt himself first of all. Hence values and feelings have more need to be universalized and made absolute on the side of the social environment; for it is to that environment that there is the most imperative need of adaptation. The life of the group must be a real working unity. In confronting its environment and the many foes which are often found there, the group must have unity of action; hence it must have unity of feeling, of values, among its members. The group as a whole needs this inner harmony on the side of feeling if it is to command the full energy, the unfailing devotion, of all its members. Its values, its emphasis upon the meaning of life, of service, and of sacrifice need to be brought to the individual in the intensest way—with that absolute sanction which only religion gives. Hence the group, like the individual, is under the psychological necessity of universalizing its values if it is to realize a full and efficient life as a group. As a part of the cultural complex of every group it is the function of religion, accordingly, to universalize values approved by the group. Religion from the start, in the stricter sense of the word, therefore, has been a social matter; and attempts to attach superhuman sanction to values, beliefs, or practises of which the society does not approve have always been branded as "black magic," or as "superstition," or as "heresy."

Hence the close connection between the customs or mores of the group, as we have already pointed out, and religion in the social sense. As a social fact religion is, indeed, not something apart from mores or social standards; it is these as regarded as "sacred." Strictly speaking there is no such thing as an unethical religion. We judge some religions as unethical because the mores of which they approve are not our mores, that is, the standards of higher civilization. All religions are ethical, however, in the sense that without exception they support customary morality, and they do this necessarily because the

values which the religious attitude of mind universalizes and makes absolute are social values. Social obligations thus early become religious obligations. In this way religion becomes the chief means of conserving customs and habits which have been found to be safe by society or which are believed to conduce to social welfare.

As the guardian of the mores, religion develops prohibitions and "taboos" of actions of which the group, or its dominant class, disapproves. It may lend itself, therefore, to maintaining a given social order longer than that order is necessary, or even after it has become a stumbling block to social progress. For the same reason it may be exploited by a dominant class in their own interest. It is in this way that religion has often become an impediment to progress and an instrument of class oppression. This socially conservative side of religion is so well known and so much emphasized by certain writers that it scarcely needs even to be mentioned. It is the chief source of the abuses of religion, and in the modern world is probably the chief cause of the deep enmity which religion has raised up for itself in a certain class of thinkers who see nothing but its negative and conservative side.

It is not our purpose, therefore, to enlarge upon this negative and conservative aspect of religion, but to discuss it as having to do with social control in a higher sense. We should remember, however, that order is the indispensable foundation of progress in society, and that even purely as a conservator of customary social values and standards religion has a great function to perform. It acts as a sort of "equilibrator" or stabilizer for social institutions. It prevents waywardness in individual character and aids in securing that conformity to type, that similarity of belief and of action, which is the essential of social solidarity. As Ward said, it acts very much in the social life as instinct does in the animal world. It insures social order and so lays the foundation for social progress.

There is no necessity, however, for the social control which religion exerts being of a non-progressive kind. The values which religion universalizes and makes absolute may as easily be values which are progressive as those which are static. In a static society which emphasizes prohibitions and the conservation of mere habit or custom, religion will also, of course, emphasize the same things; but in a progressive society religion can as easily attach its sanctions to social ideals and standards beyond the existing order as to those actually realized. Such an idealistic religion will, however, have the disadvantage of appealing mainly to the progressive and idealizing tendencies

of human nature rather than to its conservative and reactionary tendencies. Necessarily, also, it will appeal more strongly to those enlightened classes in society who are leading in social progress rather than to those who are content with things as they are. This is doubtless the main reason why progressive religions are exceedingly rare in human history, taking it as a whole, and have appeared only in the later stages of cultural evolution.

Nevertheless, there are good reasons for believing that the inevitable evolution of religion has been in a humanitarian direction, and that there is an intimate connection between social idealism and the higher religions. There are two reasons for this generalization. The social life becomes more complex with each succeeding stage of upward development, and groups have therefore more need of commanding the unfailing devotion of their members if they are to maintain their unity and efficiency as groups. More and more, accordingly, religion in its evolution has come to emphasize the self-effacing devotion of the individual to the group in times of crisis. And as the complexity of social life increases, the crises increase in which the group must ask the unfailing service and devotion of its members. Thus religion in its upward evolution becomes increasingly social, until it finally comes to throw supreme emphasis upon the life of service and of self-sacrifice for the sake of the group; and as the group expands from the clan and the tribe to humanity, religion necessarily becomes less tribal and more humanitarian until the supreme object of the devotion which it inculcates must ultimately be the whole of humanity. Again, religions have, for the most part, in the later stages of culture, after they have passed through the period of ancestor worship, gotten their social ideals from the family life; and sociology shows that the social and moral ideals of higher civilization in general also have come from the primary forms of association, such as the family.[6] Now social idealism is an attempt to realize in the wider social life these primary ideals which are gotten from primary groups; and as the higher ethical religions got their ideals from the same source they have the same aim. The higher, or so-called "ethical" religions, are, therefore, but manifestations of social idealism imbedded in religious feeling and accompanied by more or less formal religious sanctions.

A somewhat detailed study of religious development would of course be required to throw a fuller light upon the necessity, the universality, and the function of religion in human society.

[6] Cooley, "Social Organization," Chap. IV.

No one can understand religion, as has been well said, without understanding other religions than his own, any more than one can understand language without understanding other languages than his own. The scientific student of religion must recognize, as Marett says, that there is a "soul of truth" in all religions.[7] At any rate no religion lies in utter isolation from other religions, and from the most highly developed to the most lowly there are intellectual clews running back which are of the utmost value for the understanding of the relations of religion to civilization. Let us very briefly sketch, therefore, the evolution of religion.

If we take the commonly accepted seven stages of religious evolution, namely, pre-animism, animism, totemism, ancestor worship, polytheism, henothism, and monotheism, it is not difficult to see that they not only embody man's valuation of his world but also the social values of the age which they represent. Thus in the pre-animistic stage we have every reason to believe the conception of the "sacred" arose, as illustrated, for example, in the Melanesians' conception of "Mana." This word was used by the Melanesians to signify a power or influence not visible, and in a way supernatural, showing itself in connection with both persons and natural objects.[8] Fear and reverence were always attached to any person or thing which manifested "Mana," and thus such persons or things were "taboo"; and upon this idea of taboo the whole conception of the "sacred" as a means of social control seems to have been built up. The world was filled, in other words, with a mysterious, wonder-working energy which was the source of all success, luck, or good fortune, and which must be dealt with in a certain way in order to insure these desirable effects both for the individual and for the community. The American Indian had much the same conception in such words as "Manitou" and "Wakanda," and among many other primitive peoples we find parallel conceptions. Nothing was more important for the individual or the community in this stage than to put itself into right relations with this mysterious, wonder-working power which assured good or bad fortune. Hence already, though there were no "gods," the whole mental and social machinery of religion was at work with respect to the mores in the way which we have already described at the beginning of this paper.

The second stage of religion came when this mysterious, wonder-working power was conceived of as a "double" or a "spirit" which resided in men, animals, and things. This

[7] "Anthropology," Chap. VIII.

[8] Codrington, "The Melanesians," p. 118 f.

stage is known as "animism." The mysterious, wonder-working power was conceived as able to exist apart from the object in which it resided. Thus was born the conception of the "soul," a conception which was bound to be reached by man's power of abstraction, but which was made easier through man's reflection upon the experiences of his dream-world. Out of the dualism of the ordinary and the extraordinary, the natural and the supernatural, grew the further dualism of the physical and the spiritual; and the mysterious, wonder-working powers were identified with the spiritual beings, the "souls" or "doubles" of men, animals, and things. A further step in the development of religion is shown in animism, because man now more definitely interprets his world in terms of himself, of his will, and of his values. This stage prepared religion to develop and emphasize the subjective element, and to make it the chief element in social control.

A third stage of religious development was "totemism," in which animals or plants became the chief objects of religious veneration. The totemic stage arose naturally from the animistic, and marked a broadening of man's knowledge concerning his world. It was correlated with the hunting stage of economic development. Man was surrounded by animals, he hunted animals, he lived on animals, he thought in terms of animals, and therefore, he mainly worshipped animals. It was the zoomorphic stage of religion. The mysterious wonder-working power was the animal or plant which was regarded with religious reverence and conceived of as having some mysterious relation to the group, which usually bore its name. Kinship and religion now become definitely allied, and hence we may say that this was the first stage in which religion came to have an organized control over all the forms and relationships of social life. Art, education, and food-getting, also, now come under well-defined religious control.

The fourth stage of religious development, the hero-ancestor-worshipping stage, did not arise until the patriarchal family and pastoral industry, together with the power of the war chief, emphasized the human element. Thus the anthropomorphic stage of religious evolution was reached. The mysterious, wonder-working powers were now conceived to be the souls of departed heroes or ancestors. Each family had its own gods and its own domestic worship. This stage fostered the development of the domestic virtues, accordingly, and of the social ideals derived from the domestic virtues; but it had a great drawback in that, by apotheosizing the departed ancestor, it emphasized too much the values of the past. Religion took on

an ultra-conservative nature and made possible such static civilization as was, for example, illustrated for centuries by the Chinese. The abuses of religion, from a social point of view, now begin to appear.

When small ancestor-worshipping groups were welded into city-states or small nations, the gods of the different groups, who included not only the heroic ancestors of the past, but also many nature spirits whose worship had survived from animistic times, formed a "pantheon," and we have the stage of religion which is known as "polytheism." In this stage there is a classification of gods. Not every blade of grass had a god, but there might be a god of the grass. Neither did every man have a god, but there was a god for practically every social activity of man, a god of war, a god of love, etc. All were highly personalized beings, and the community of gods was conceived as more or less like the community of men, though often idealized. This stage was really transitional, and is marked by a confusion of ethical and religious conceptions and values. There was in it, therefore, the opportunity for the sanction of all sorts of practises, and the abuses of religion become more manifest, as seen, for example, in the various practises of idolatry.

Out of polytheism slowly developed another intermediary stage of religion known as "henotheism," in which one of the gods of the pantheon was chosen by a people as its particular national god, without their denying at first, however, the existence of other gods. Gradually the other gods came to be regarded as "false gods" and the national god as the true god. All monotheistic peoples have passed through this henotheistic stage, though students of religion have sometimes failed to recognize it. The early Jews, for example, before the later prophets were unquestionably henotheistic. This national stage of religion[9] served greatly to unify peoples in strong nationalistic groups. It is a serious question whether our civilization is not yet mainly in this stage of religion. Religion in this stage is crudely anthropomorphic, and the deity is thought of as having the national character of the people with very definite human traits.

True monotheism is reached only when the mind of man sees that there is but one universal existence from whence all things, including his own mind, have proceeded and of which they are a part. Monotheism, in other words, is the recognition of the infinite as God, that infinite and eternal energy from

[9] Some special term like "henotheism" is certainly needed to designate the strongly marked "national" stage of religious evolution.

which all things proceed and to which all things return. Such a conception has tended in our civilization to take the form of an ethical theism, and probably rightly, since mere "energism" satisfies neither the emotions nor the intellect of man. The one distinctive contribution which modern science, indeed, has been able to make to religious thought on the theological side is the recognition of the fact of "creative evolution," that the energy of the universe is "an ascending energy." Thus under ethical theism the highest social values have been readily given a religious sanction, that is, universalized or projected into the universe. Hence social idealism has been stimulated by ethical monotheism as never before in the history of civilization.

Now this rough outline of the development of religion shows clearly enough that religion has evolved with the social and mental life of man; that it is a thing which changes with the whole cultural complex which we call "civilization"; and that changes in religion have had much to do with changes in man's social and cultural life in general. Clearly enough, too, human history has been, from one point of view, a struggle to attain to a rational and truly social religion—such a valuation of all the experience of life in terms of the universe as accords with man's reason and yet intensifies his social values. Only to an absolute skeptic would the great revolutions in religion appear other than as steps in social and cultural progress. But what will the next revolution in religion bring forth? Will it not be "atheism," as so many have said?

It hardly needs to be pointed out to the student of civilization that we have scarcely yet attained to a true ethical monotheism; that we left henotheism behind but yesterday, and that still the peoples of the world are prone to relapse into it. Ethical monotheism may, indeed, be a form of religious consciousness to which the masses of mankind never can attain, but if cultural progress continues religion should develop in this direction, if we can judge from its past history. Monotheism is not outgrown; we have not yet grown into it. We need a more social and ethical form of it rather than a theological and metaphysical conception merely. The religious revolution which now confronts us, in other words, concerns the transition from theological to ethical monotheism, from a metaphysical to a social conception of religion.

But it may be asked, why should social values be expressed religiously? Is not the fact that they are social values, built up from the real experiences of mankind, sufficient sanction for them without attaching to them theological or mythological notions? This form of the question, however, indicates a mis-

understanding. For a religious sanction given to social values does not necessarily imply the attachment to them of any *definite* theological notions; it only implies that they are made universal and, as it were, absolute. The history of the evolution of religion shows this very conclusively because *theological notions have constantly changed, but religion has remained.* It is true that there is a minimum of theology and of metaphysics which remains in all religion and which is necessary to it. But the same statement is equally true of science. Religion refuses to negate the universe, to deny the reality of existence, of life, or of mind. But equally so does science. Religion can not build itself upon negations; but neither can science, nor art, nor education, nor any of the other practical social activities of mankind. All such practical social activites are necessarily built upon a common-sense, constructive attitude toward "the system of things." Religion assumes, of course, that the system of things is not alien to ourselves. We can not rule theology out of religion altogether, any more than we can rule metaphysics out of science; but the place of theology in religion during the past few generations has been much exaggerated, and this has been one of the main impediments to the attainment by our civilization of a rational and humanitarian religion. The recognition that religion is a thing which exists independent of *definite* theological doctrines is necessary, therefore, for its free development, though this statement should not be interpreted to mean that we can build a religion, any more than anything else, upon a negative attitude toward life, mind, or the universe at large.

The religious problem, then, is not the problem of merely maintaining religion in human life. For reasons which we have seen there is probably no such problem as that; for if we do not have a rational and ethical religion, the mind of man is such that we are bound to have irrational and unethical religion —if not a religion of social progress, then a religion of social retrogression and barbarism. The religious problem of our age is what the religious problem of every age has been, the problem of getting a religion adapted to the requirements of our present social life. But the requirements of social life are at present so much more complex than in any other period of human history that a socially superior religion is needed. The modern man lives in a more complex world in which the difficulties of adjustment are so great that pessimistic writers are wont to tell us that humanity has about reached its limits of adjustment. At the same time higher intellectual development makes it more necessary for the modern man to see a meaning

in things beyond mere appearances if he is to adjust himself successfully to them. Finally, the delicate interrelations of all parts of our civilization make a stronger and more universal good will necessary, if social calamity is not to overtake us. Never before in the history of the world, then, did rational social values need more the sanction of religion than at present, because never before did they need to come to the consciousness of the individual in intenser form. The limits of adjustment have, of course, not been reached by humanity; in fact no one can scientifically set the limits of possible human adjustment. But in the new and complex world in which we now live, in which the interdependence of man and man reaches to the uttermost bounds of the earth, we need more of the guidance of reason and at the same time a stronger motivation for making complex social adjustments. In other words, while we need science, we need, not less, confidence in our world and universal good will towards men. That is to say, we need religion and morality not less than science, to meet the problems of more complex human living together. Those who are interested in the development of an harmoniously adjusted social life for humanity as a whole can not afford, therefore, to ignore religion as a means of social control; for, as we have tried to show, the more complex social life becomes the more impossible is an adequate social morality without a correspondingly high development of social religion.

Obviously, it is only a rebirth of humanitarian ethics which can save the world from its present welter of seemingly unending class, national, and racial struggles. But humanitarian ethics demands more in the way of self-sacrifice from the individual than class, tribal, or national ethics. It makes the least appeal of any system of morality to the natural egoism of the individual because it concerns the largest possible human group, having to do with the welfare of many individuals of whose existence the average individual knows nothing directly through experience, and concerning whose welfare he can have tangible ideas only through the exercise of the liveliest imagination. Humanitarian ethics, in order to be successful, must be supported by a religion which will stimulate a humanity-wide altruism in the individual. It must have the support of a religion of humanity. The social significance, then, of the attempt to develop in the higher stages of social and cultural evolution a humanitarian religion, a religion which sets up the love and service of humanity as the highest manifestation of religion, is nothing less than that *it is the process by which social evolution is endeavoring to transcend individual, class,*

tribal, and national ethics and to replace these by a social, international, humanitarian ethics. This is the significance of the religious problem and of the truly progressive religious movements of our day.

But in the meanwhile retrogressive tendencies have also shown themselves in the religious life of western civilization—tendencies which threaten to defeat the normal evolution of religion into the humanitarian type. What then is to be done? The creation and establishment of a new religion under the complex conditions of modern life is almost out of question, because there would be little chance of such a venture becoming successful in time to perform the services which are needed for the control of our world-wide civilization. Nor is such a venture necessary; it is only necessary that the leaders of religion of our day grasp the social significance of religion in our civilization and give it the positive humanitarian trend which the situation demands. Fortunately, the most advanced religions of our time have already attached themselves more or less formally to the cause of humanitarian ethics. This is especially true of the most advanced Christian sects. All that is needed, therefore, is that the churches of to-day should drop theological disputation, recognize that their essential work is the maintenance and propagation of rational social values, and teach clearly that the only possible service of God must consist in the service of men, no matter what their class, race, or nationality may be. In this work the churches would not only forget their traditional differences, but it is probable that they would rally to their support a very large part of those who are now their active opponents.

Let the recognized basis of religious fellowship, in other words, become full consecration for the service of mankind, and all the irrational, unsocial, and unprogressive elements in our religious life would then disappear. We should then have a religion adapted to the requirements of our social life, and a basis of social control adequate for the highest civilization. There have been many stirrings in this direction in religious circles within recent years, but they are as yet far from fruition. After this war is over, if not before, however, it is to be hoped that we shall take seriously in hand the reconstruction of our religious life along humanitarian lines. For an actually realized humanitarian religion, sanctioning and enforcing a humanitarian ethics, would be our surest guarantee of establishing social justice and future good will between classes, nations, and races, and the surest preventive of the recurrence again of such a calamity as the present war.

THE METHOD OF NATURE

By Professor I. W. HOWERTH
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NATURE is creative. This is no new and profound idea originating in the mind of M. Bergson; it is a patent and familiar fact lying on the surface of things. Creation is merely the production of something new. Man creates, but only by application of the creative principles of nature. Nature's creations do not differ in any essential respect from the created products of man. When two or more chemical elements combine by chance in certain proportions the result is something new, something entirely different from either constituent; a product manifesting new properties; it is a creation of nature. Such, for instance, are all the gases, liquids and solids, which go to make up the visible universe. Some of these man recreates by a process of creative synthesis, as, for instance, in synthetic chemistry.

If, then, we conceive the existing universe as having been evolved gradually and naturally, that is, from the operation of inherent forces, and from diffused matter consisting of a few elements or of one; or, in other words, if we accept the current doctrine of evolution; we must recognize that all the various forms of matter, with all their peculiar properties, have come into existence at certain definite times in the past in a natural manner. From a state of existence *de potentia* they passed, sometime and somewhere and for the first time, into a state of existence *de facto*. They were, therefore, at their initial appearance, absolutely new creations. The order of their appearance was more or less serial. Roughly speaking, it was perhaps as follows: the atom, the molecule, the inorganic compound, the organic compound, protoplasm, protists, plants, animals, man, society. The principle involved is that of combination. Nature creates by compounding. Creation is permutation.

Nature, then, is not only "*durch und durch causalität*," as Schopenhauer declared; it is through and through creative. All that now exists, whether in the inorganic, organic, or social worlds, save the relatively few products of man's intelligence, is the outcome of a natural creative process and the manifestation of a natural creative power.

Confining attention, for our present purposes, to the creative principle as manifested in the organic and social worlds, we find it marvelously exemplified in the manifold and myriad forms of plant and animal life, and in the social groups and institutions which have come into existence spontaneously.

With respect to plants and animals there are now known and classified more than two million species, and the number is increasing every day. In the classification of Linnæus, made in 1758, we find included only 4,136 species of animals. In modern classifications the number is multiplied more than a hundred fold. A recent writer places it at 716,000. A speaker at the American Society of Zoologists in 1912 gave a total of 522,400. Jordan and Kellogg, in their book entitled "Animal Studies," state that there are 300,000 named species of insects known to zoologists, and that this number represents only one fifth, or possibly one tenth, of those living throughout the world. Herbert Spencer, in 1852, on the authority of Humboldt and Carpenter, placed the number of animal species at 320,000 and of plants at two million, and declared that

> If to that we add the number of animal and vegetable species that have become extinct, we may easily estimate the number of species that have existed and are existing on the earth at not less than ten millions.

Now what created all these forms of life with their infinite variations? Nature. The orthodox religionist would use the interrogative "who," and answer, "God;" and there need be no objection to that reply. But inasmuch as science deals only with secondary causes, not at all with ultimates, the scientific answer must be as given; and there should be no objection on religious grounds to the answer thus made.

Nature, by a distinctively creative process, then, brought into existence all the various species of plant and animal life, and animal and human societies, too; and controls them all in so far as they are not products of conscious human effort. We are aware that an objection may be raised to thus objectifying nature and apparently separating it from its products, but such separation appears to be a necessity of speech, and, aside from noting the possibility of such objection, it need not detain the argument.

Now, nothing is produced, accomplished, or achieved without some describable mode or way of procedure. The mode or way in the process of human achievement is denominated method, and, by a figure of speech, we may employ the same term in describing the creative process of nature. What, then, is nature's method of creation?

In spite of modern criticism of the Darwinian hypothesis, which appears oftentimes to be over-refined or misdirected, it may be said that the method of nature is most adequately described as a process of natural selection, meaning by that expression all that may be rightfully implied. Darwin himself admitted that other factors are involved in the process.

Taking natural selection, then, as the most important means or method of natural creation, we wish to point out some of its most conspicuous characteristics, the range of its application, and the folly of relying upon it for the realization of desirable human ends.

The first element which reveals itself in an analysis of the principle of natural selection is a "multiplication of chances." This is required to furnish opportunity for selection and is occasioned by the fertility of nature. Nature brings into existence many more organisms than can possibly survive. This is necessary in order to secure the requisite number and kinds of variants in a given type of organism to secure survival of the species and progressive adaptation. But it means, so far as any special and particular result is concerned, an enormous waste. The first, and most obvious, characteristic of nature's method is its extraordinary wastefulness.

To appreciate the waste of nature one has but to compare its potential with its actual achievement in the perpetuation of a given type of organism. Among microorganisms the possibilities of increase in number are most astounding. A minute form of life, *hydrotina*, is capable of producing offspring with such rapidity that, in a single year, they would form a sphere whose limits would extend beyond the confines of the known universe. A certain infusorium, *stylonichia*, is said to be capable of producing in six and one half days a mass of protoplasm weighing one kilogram. In thirty days, at the same rate, it could produce a mass a million times larger than the sun, the weight of which in kilograms would have to be represented by a figure followed by forty zeros.[1] A plant which produces only two seeds a year, and there are few, if any, that are not more prolific, would have in the twenty-first year, if none was destroyed, 1,048,576 descendants. A horse-chestnut tree may produce a ton of pollen. A housefly lays a hundred and twenty eggs, and there are twelve to fourteen generations in a season. Counting twelve generations only, a single fly, if all its offspring survived, might be the parent

[1] For these and other striking illustrations of the potential fertility of nature, see Morgan, "Heredity and Sex," p. 2; Marshall, A. M., "Lectures on the Darwinian Theory," pp. 39–40.

of a family numbering 4,253,564,672,000,000,000,000. A salmon lays 15,000 eggs, an octopus, 50,000, a large shad, 100,000, a codfish 1,000,000, an oyster 2,000,000, a conger eel 10,000,000, a tapeworm 1,000,000,000. In 1864 a man living on a sheep ranch near Melbourne, Australia, imported, from the Kew Gardens in London, three pairs of rabbits. In 1906, forty years afterwards, Australia shipped to Europe 25,000,000 frozen rabbits, and 96,000,000 rabbit skins. Horses were introduced in Buenos Ayres in 1537. In forty-three years they had spread to the Straits of Magellan. Fertility diminishes as we rise in the scale of animal life, but even the human being is capable of reproducing with such rapidity that from a single pair, doubling once in fifty years, there would be in three thousand years a sufficient number of human beings to cover the whole surface of the earth, land and sea, and piled on top of one another eight hundred deep. Such are some of the illustrations of the potential natural increase of organisms.

Notwithstanding this enormous fertility of nature, in spite of this enormous multiplication of chances, it is a well-known fact that the number of any given species remains, as a rule, practically the same from year to year. What becomes of the surplus? Why is it that "of fifty seeds She often brings but one to bear"? Obviously the surplus production is wasted, at least so far as the perpetuation of the given species is concerned. Says Asa Gray:

> The waste of being is enormous, far beyond the common apprehension. Seeds, eggs, and other germs, are designed to be plants and animals, but not one of a thousand or of a million achieves its destiny. . . . But what of the vast majority that perish? As of the light of the sun, sent forth in all directions, only a minute portion is intercepted by the earth or other planets where some of it may be utilized for present or future life, so of potential organisms, or organisms begun, no larger proportion attain the presumed end of their creation.[2]

Nature's economy, then, is no economy at all; its order is disorder; its method is the absence of method, if that word be defined in terms of human procedure. The most conspicuous characteristic of nature's mode of action in the process of creation, or of perpetuation, is waste.

This waste is manifested not alone in the number of material products destroyed but also in the amount of time required to produce a given result. Lamarck perceived this. He said,

> For nature time is nothing. It is never a difficulty, she always has it

[2] "Darwiniana," by Asa Gray, New York, 1877, pp. 372–373.

at her disposal; and it is for her the means by which she has accomplished the greatest as well as the least results.

It required millions of years to fashion the earth, millions to populate it with the lower orders of life, perhaps a million to develop man, and thousands of years to produce a civilized people. The method of nature is slow.

Still another, and perhaps more significant fact, is that the method of nature is uncertain, so far as the realization of results desirable to man is concerned. This arises from the absence in all purely natural processes of the aims and purposes of man. All movements of nature, as far as we are able to trace them, are in the direction of balance or adjustment. As to whether the resulting conditions, or the products created thereby, are profitable to man, nature is wholly unconcerned. Whatever else it may be, nature is not Providence. According to the law of probabilities, it must sometimes happen, of course, that in the manifold activities of nature, and in the multiform products resulting from those activities, something will be found conforming to human desires, and certain processes will be directed toward the achievement of desirable human ends. Nevertheless nature is aimless, and the human benefits resulting from the operations of nature's method are wholly accidental.

Such, then, are the leading characteristics of the method of nature; it is wasteful, slow, and aimless, therefore uncertain so far as the production of desirable human results are concerned. Let us now observe the range of its operations.

Obviously the method of nature applies to all movements, and to the creation of all products, in which intelligence is not involved. Such, for instance, are the creation and movements of the planets, of the clouds, of the waves of the sea, of the earth and the convulsions in its crust, and the creation and development of all plants and animals in a state of nature. It should be equally obvious that it applies, also, to all incidental, that is, all unintended, results of intelligent action. But much that happens in human life is incidental to the pursuit of conscious ends; it falls outside of the purposive; it is fortuitous, accidental, and belongs, therefore, in the realm of nature; and anything resulting from it is achieved by nature's method.

With this understanding it is easy to see that many, if not most of the movements of society, whether progressive or regressive, take place in accordance with the method of nature; they are unintended, wholly incidental to the human pursuit of other ends. For it is an obvious fact that individuals in

pursuit of strictly personal ends, and corporate bodies in the pursuit of corporate ends, may affect society for good or ill. So far as society is thus affected it is under the control of nature. Social movements thus produced, social products thus created, are without conscious intent on the part of anybody. As a matter of fact most social movements, most of the social progress of the past, and much of that of to-day, are, socially considered, unconscious and unintended.

Society to-day, then, is still, in large part, under the domain of nature, and the progress achieved is still largely the result of the operations of nature's method. Such progress is, therefore, wasteful, slow, and uncertain. War between social groups, and for national rather than social purposes, and business competition for corporate or individual ends, are often socially progressive in results, but the progress achieved by them is attained by nature's method, and is therefore as wasteful, slow, and uncertain as any of the other operations of nature.

With some of the lower organisms, the domesticated plants and animals, the method of nature has long since been supplanted by artificial selection, and the other more economical methods of mind. Waste is eliminated, development is hastened, new types are developed, change is directed toward a predetermined goal.

The same thing might be and should be true of social change. As society is a product of nature, and its movements subject to natural law, it may be modified by the intelligence and will of man. Its progress, as achieved by the method of nature, is wasteful, slow and uncertain. We should no more rely upon the method of nature to bring about a high form of civilization than we should rely upon that method to bring into existence the particular types of plants and animals most serviceable to man. He who hopes that the natural method of social development will of itself produce democracy, for instance, or permanent peace, or that the brotherhood of man will inevitably be reached as a natural goal, is in like case with the foolish optimist who expects a good crop to be grown without cultivation or a Micawber who expectantly waits for something favorable to turn up. It is man's prerogative to supplant, in the whole field of natural phenomena, the method of nature by the method of mind, and thus to control social events and social progress as he has long been controlling the progress of the domesticated plants and animals, and many of the processes of the physical world.

If this idea, and this possibility, ever should become real-

ized, they must necessarily involve, as a preliminary step, the development of a social consciousness as distinguished from the narrower group consciousnesses which now prevail, and in which the latter will merge. This necessarily means a league of nations, and the surrender, on the part of national groups, of independent national sovereignty. To the idea of the necessity of such a league many have already come. The conception is generally limited, however, to that of a league to secure and maintain international peace. But, if the method of nature is to be supplanted in the progress of society, the functions of such a league must be carried far beyond the establishment and maintenance of peace. It will not be enough to create a league within which the method of nature is to operate in the wasteful, even though peaceful, struggles of groups, in a "war after the war." There must be definite, constructive purposes looking to the elimination of strife and petty jealousies, and the organization of all the resources of society in the interest of human happiness. The internal operations of society must also be brought under social control, and social control, no matter where it is exercised, means the supplanting of nature's methods by the more economical methods of intelligence.

A league of nations, then, is necessary, and we do well to urge its formation. But if social progress is ever to become orderly, if we are ever to eliminate its terrible waste, if social change is ever to become certainly progressive, if we are to approach with even pace the social conditions of which already many have dared to dream, the method of nature must be supplanted everywhere throughout the realm of human interests, and society become a work of art, and not remain as it now is, largely a product of nature. Can this be done? Is man, who controls with such wonderful results the physical forces, and who determines in large measure the destiny of all lower creatures, powerless to determine the destiny of society? Shall it be said of Man, as it was said of the Son of Man, "He saved others, himself he cannot save"? The achievements of science in every domain of natural phenomena, the gradual extension of a social art based on a science of society, deny it, and give ground for a more optimistic social philospohy.

THE CHEMISTS OF AMERICA

By Dr. BENJAMIN HARROW

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At a recent meeting of the Washington Academy of Sciences, the chemical representative with the British mission in this country told the audience that the side with the best chemists will probably win the war. This is worth remembering when our statesmen fill themselves, the newspapers, and the people with war knowledge.

Perhaps some will take our Britisher to task for giving undue importance to his sphere of activity. If so, let the facts speak for themselves. Until shortly before the outbreak of the war the nitrate supply of the world came from Chili. With it the world's supply of fertilizer was satisfied; with it, nitric acid, and hence our various modern explosives, were manufactured. But the deposits, like those of coal, have their limits; and the world's needs were emptying the nitrate deposits even faster than those of coal. The situation was alarming but not hopeless, for at this point the chemist stepped in and suggested a solution. Approximately eighty per cent. of the air we breathe contains nitrogen. But this element, in the free state, is useless for most purposes—whether to feed the soil, or feed man, or prepare munitions. And to combine it with oxygen to get the necessary nitrates is not an easy matter. However, the chemists attacked the problem. Particularly so the chemists of Germany.

As soon as war was declared, Germany's supply of Chili saltpeter was cut off. But by that time her chemists had solved the problem of the fixation of nitrogen—as the process by which the nitrogen of the air is converted into nitrates is called.

There is much plausibility in the assertion that the militaristic clique in Prussia awaited but the solution to this problem before finding a convenient pretext for war.

When, after the battle of the Marne, defeat stared the Prussians, who helped them to stave off defeat? The chemist with his gas. And when our allies had developed effective counter-measures for this added horror of modern warfare,

the German chemist introduced the gas shell. It is now being pretty generally conceded by those in a position to know, that the recent German drives on the western front have been made possible not merely because of added numbers from the East, nor because of Von Hutier's new form of attack, but to a large extent on account of a prodigal expenditure of "mustard" gas. Re-read the story of the evacuation of Armentières.

What has saved Germany thus far is not her organization, nor her generals. It is her chemists. Every one talks of Hindenburg and Ludendorff. But how many have heard of Baeyer and Fischer?

Let not the reader, however, get the impression that Germany has a monopoly of chemists. By no means. Germany has made much of her chemists, whereas we have neglected ours. The German government, through its industrial organizations, has constantly encouraged them to further efforts; our statesmen, steeped in Greek, Latin or Tammany classics, have not.

But the dawn of a brighter day is arising. The world tragedy has opened the eyes of our people. When peace and goodwill once again reign among us, let us hope that the leaders of at least two of our great democracies will take the lesson to heart—not, indeed, to encourage their scientists to devise further, and more horrible means for conducting warfare, as is done by the present German government, but to encourage our plodding philosophers in the search they love best—unfolding the secrets of nature, thereby adding to the knowledge and happiness of the world.

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Chemistry in America is a very young product. It probably received its impetus from the Englishman, Priestly, the discoverer of oxygen, who came to these shores in the latter part of the last century, and from Robert Hare, the inventor of the oxy-hydrogen blowpipe. The flame was kept a-burning by a succession of well-known teachers at Harvard and Pennsylvania, among whom may be mentioned Cooke and Wolcott Gibbs. The more modern period was ushered in by Charles Eliot in Boston, Ira Remsen at Johns Hopkins, Frederick Chandler at Columbia, and E. F. Smith at Pennsylvania.

From small beginnings the science has enlarged a thousandfold. Our American Chemical Society has a membership of 10,000. It publishes an erudite journal, devoted to recording the results of research by its members; a chemical abstracts,

embracing a digest of the world's chemical literature; and an industrial journal which, in the last four or five years, has become unrivaled.

Germany has for so long appropriated the ideas of some of the master minds of Britain and France, that it is a rather welcome sign to find the Americans turning the tables upon the Germans now. Some of our leading chemists have received their post-graduate training in Germany. These men are making use of their training with a vengeance. Apart from their immediate services to the government, these men have, during the last twenty-five years, trained the younger generation to a degree which has called forth the admiration of their German masters. Even before the war, the number of American chemists at German universities showed a marked falling off. Our post-graduate departments at Harvard, at Chicago, at California, at Columbia, at Johns Hopkins, at Yale, at Michigan, and others, have become the serious rivals of those at Berlin and Munich, Bonn and Heidelberg.

The chemical advisers of the government are directing, and the larger body of chemists are actively engaged in work on explosives, on gases, on foods, on iron and steel, on copper, on aluminum, on fertilizer, on dyes, on drugs, on rubber, on leather, on paints, on glass, on fats and soaps, on paper, on cement, etc. Who are some of these men, so indispensable for the successful prosecution of the war, and just as indispensable for the development of our country after the war?

In the mathematical branch of the science—that more particularly concerned with the fundamental properties of matter—we probably lead all other countries. Willard Gibbs (Yale), one of the profoundest mathematicians of the century, was the forerunner. Closely following upon him came Edward Morley (Western Reserve), whose work on the composition of water is among the classics in chemistry. At present there is T. W. Richards (Harvard), winner of the Nobel prize, and the great authority on the weight relationships of the elements; G. N. Lewis (California), the energy exponent, now with the oversea forces; and workers on the theories of solution and other kindred subjects; H. N. Morse and the late H. C. Jones (Johns Hopkins); W. D. Harkins (Chicago); W. D. Bancroft (Cornell); E. W. Washburn (Illinois); J. L. R. Morgan and James Kendal (Columbia); M. Rosanoff (Pittsburgh), etc.

Closely associated with these, but particularly well known as the authors of successful text-books, may be mentioned A. Smith (Columbia); J. Stieglitz (Chicago); and C. Baskerville (College of the City of New York).

In the analytical field—the detection and estimation of the elements and their compounds—we have F. W. Clarke (U. S. Geol. Survey), particularly well known for his work on chemical geology; F. A. Gooch (Yale), originator of several well-known appliances in the laboratory; W. F. Hillebrand (U. S. Geol. Survey), the author of a splendid work on rock analysis, etc.

In the field of organic chemistry, where we are introduced to glycerin, carbolic acid and toluol, leading on to the chemistry of modern explosives, we have M. Gomberg (Michigan); M. T. Bogert, in charge of the chemical service section of the National Army, and J. M. Nelson (Columbia), T. B. Johnson (Yale), W. A. Noyes (Illinois), C. S. Hudson (U. S. Dept. of Agriculture), etc. This branch of the science suffered a grievous loss a short time ago by the death of J. U. Nef (Chicago).

Again, in the most recent offshoot of organic chemistry, the application of the science to physiology, to biology and to medicine in general, we are easily the leaders. There come to mind the names of such men as O. Folin (Harvard), who has revolutionized clinical chemistry; P. A. Levene and D. D. Van Slyke (Rockefeller Institute), R. H. Chittenden and L. B. Mendel (Yale), E. V. McCollum and W. Jones (Johns Hopkins), W. J. Gies (Columbia), H. D. Dakin (Herter Laboratory), C. Funk, C. Alsberg (Chief Chemist, U. S. Dept. of Agriculture), K. G. Falk (Harriman Research Laboratory), P. B. Hawk (Jefferson Medical College), A. E. Taylor (Pennsylvania), G. Lusk and S. R. Benedict (Cornell), A. P. Mathews (Chicago), etc.

Closely associated with these, but more narrowly restricted to foods, may be mentioned H. C. Sherman (Columbia), H. W. Wiley, and W. D. Bigelow.

Among those particularly interested in its agricultural aspects are O. Schreiner (U. S. Bureau of Soils), C. B. Lipman (California), and T. J. Lipman (Rutgers).

Though J. Loeb (Rockefeller Institute) and W. J. V. Osterhout (Harvard) are directors of departments of biology and botany, respectively, their researches are wholly biochemical in nature.

As might be expected, in the industrial field, where the inventive genius finds an immediate and successful outlet, the American chemist has done wonders. Every student who takes a course in elementary chemistry knows how Goodyear vulcanized rubber, how Hall revolutionized the manufacture of aluminum, how Frasch devised an ingenious method for extracting sulphur from the Louisiana ores, how Castner invented his electrolytic process for the production of caustic soda, used

in enormous quantities in the manufacture of soap, how Acheson discovered carborundum, artificial graphite, and deflocculated graphite, and how Baekeland discovered bakelite, used in electrical appliances, phonographic records, etc. And now younger America, in the shape of W. F. Rittman, is busily engaged in perfecting a process for "cracking" petroleum under pressure, whereby an amazing number of raw products necessary for explosives, and dyes, and motive power, are formed. And again, one of Parr's students at Illinois has developed a method of extracting the dye from the wood of the osage orange, which dye is now used for the khaki uniform cloth of the American Army.

But this is not all. Bucher, of Brown University, and the chemists of the General Electric Company, are rapidly concluding their researches into a practical method of extracting the nitrogen from the air; Day, of the Geophysical Laboratory, is preparing an optical glass which is superior to the German product; and various biochemists are putting on the market Salvarsan, substitutes for cocaine, adrenalin, and dozens of other German-made substances badly needed by our medical men.

And so the story goes.

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A most encouraging augury for the future is the close cooperation that is beginning to exist between the universities, on the one hand, and the industries, on the other. For much of this our thanks are due to the late R. K. Duncan, for some years the director of the Mellon Institute at Pittsburgh, and the originator of the Mellon Industrial Fellowships. Incidentally, Duncan's two or three books on popular chemistry remind one of a Huxley or a Tyndall.

An even better sign of the times is the research laboratories that our industrial corporations are establishing. A model of its kind is the chemical laboratory of the General Electric Company. Its two chief chemists, W. R. Whitney and I. Langmuir, are among the leaders in their profession in this country.

THE JURASSIC LAGOONS OF SOLNHOFEN

By Professor EDWARD W. BERRY

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THE aim of the true paleontologist is the elucidation of the history of the earth, and by the term earth history I do not mean merely the physical history, but also the biological history, so that the result will be a complete picture of the relations of land and sea, the inhabitants of both, the climate, and the steady progress of events—both organic and inorganic.

Such a picture is one of almost infinite complexity, as we at once realize when we endeavor to comprehend the mutual relations of a single flora and fauna to one another and to their physical environment in even a small area of the earth's surface at the present time. If it is almost impossible to arrive at correct results in dealing with a contemporaneous flora and fauna, how much more difficult is it to deal with the often fragmentary remains that represent a mere fraction of the life of five or ten million years ago.

Shall we then merely accumulate bricks and wait for the master builder of the future to build our temple? Already the bricks have accumulated in piles, mountain high, that threaten to bury us, and we sigh for the master builder that never comes. The older paleontologists, taking their cue from the scholasticism of medieval speculation, drew pictures of Carboniferous or Jurassic landscapes and seascapes with a facile hand, but they were mostly catastrophists, and their materials were largely subjective rather than objective, so that to-day their results are considered largely fanciful.

It is a most useful practise for the scientist to follow the example of mercantile concerns and to periodically take an inventory of stock on hand, make up a balance sheet and write off the discarded theories, hypotheses and misunderstood interpretations of facts with which his subject rapidly becomes cluttered. For some geological times or in some areas the record is so imperfect that the task is hopeless. For other times and in certain favorable regions we can gather the various threads derived from a study of the sediments, from the fossil animals and fossil plants, and weave these threads into a definite pattern.

Such a region, a region with one of the most remarkable known assemblages of life—from earth, air and sea—is that of the lithographic stone quarries of South Germany. There is scarcely a museum throughout the world that does not contain some specimens from the Solnhofen lithographic stone, and while the Solnhofen quarries are less rich in fossils than others in the immediate vicinity, as for example those of Eichstädt, little attention has usually been given to exact horizon or locality.

Johannes Walther has given us an exhaustive summary[1] and drawn a picture of the life and environment of the late Jurassic at the time the lithographic stone was being deposited which in many ways should serve as a model and an inspiration for similar attempts for other times and in other areas. This scholarly work leaves little to be desired in the way of facts. The interpretations of these facts, however, made before we knew very much about the origin of such fine-grained calcareous muds as formed the commercial lithographic stone, are not always the only or the most likely deductions permissible.

Let us first of all glance at a few of the main features of Jurassic geography before describing Solnhofen and the relics of bygone life that are found there. What we now know as the Jurassic period of earth history was called the Oolite by William Smith, the father of stratigraphic geology, because of the frequent occurrence in the rocks of this age of oolitic limestones or limestones made up of tiny calcareous concretions that resembled fish roe. These were famous building stones, so renowned even that the monuments that marked the Mason and Dixon line between the dominions of William Penn and those of Lord Baltimore were of this material imported from the quarries at Portland on the south (Dorset) coast of England.

Alexander Brongniart, in 1829, proposed as a substitute for Smith's name Oolitic, the term Jurassic because of the extensive development of the rocks of this age in the Jura Mountains. Smith had divided his Oolitic series into many subordinate zones based upon their characteristic lithology and fossils, and these he grouped into three major divisions. The lower was called the Lias, the middle Dogger and the upper Malm—these all being local quarrymen's names in England that are still largely used in geological literature. They correspond to what Leopold von Buch, another grand old man of geology, in 1839 called the black, brown and white Jurassic. The Solnhofen

[1] "Die Fauna der Solnhofener Plattenkalke," Bionomisch betrachtet, Jena, 1904.

deposits fall in the third or youngest of these subdivisions—the Malm or white Jurassic.

During the long ages of the Triassic period the Paleozoic highlands of Europe had been very largely worn away by the slow processes of erosion, and the Jurassic history is in the main one of shallow seas gradually expanding over a land surface of low relief, and culminating in the almost complete flooding of the continent. North America, on the contrary, presents a striking contrast to Europe, for it is only in the Pacific coast region, and in Alaska, Texas and Mexico, that any marine Jurassic sediments have been discovered.

The Jurassic seas of Europe were prevailingly shallow and warm. They swarmed with life of all kinds, and their sediments were predominantly calcareous. The history of these successively expanding and contracting Jurassic seas, and of the teeming life of their waters, is a long and an intricate story —too long to be attempted in the present limited space. Possibly if it had not been for the regular succession of the strata and the abundance of beautifully preserved fossils in the Jurassic rocks of England, France and Germany, we should still be ignorant of the bearing of fossils upon stratigraphic succession and correlation. Certainly the rocks of no other age show so clearly the interrelations and replacements of what are usually called faunal facies, as do those of Jurassic time as they are traced from place to place.

The Solnhofen deposits came at a time just subsequent to the maximum extension of Jurassic seas which had occurred in the immediately preceding times, the rocks of which now constitute the Oxfordian and Kimeridgian stages. That the seas still covered a goodly portion of Europe is shown by the accompanying sketch map. This stage of the upper Jurassic is known as the Portlandian (from Portland, England) or Bononian (from Bononia, the old name for Boulogne, France).

Such a map, while based upon the synthesis of a vast number of observations, is necessarily conjectural in areas where rocks of this age are absent or unknown, and it then has to be determined if they had once been present and were subsequently eroded, or whether this particular area was above the sea at that time. Moreover, errors in the correlation of distant strata are fruitful sources of misconception, and, finally, since even the map for a single stage covers some tens of thousands if not hundreds of thousands of years during which the coast lines were gradually changing, it is obvious that such a map can only approximate the true geography of any time and might aptly be

compared with the awkward-looking snapshot of a running animal as contrasted with a motion-picture film of the same animal.

Turning now to the accompanying map, it will be noted that Europe was an archipelago at that time, not unlike the East Indies of to-day. The largest island, probably of a much more irregular outline than I have indicated, embraced Scandinavia, Finland and northwestern Russia. No traces of Portlandian sediments have been found in this vast region except in the lined area indicated around its margin. A shallow open sea appears to have covered most of Russia, broken by large islands in the Caucasus, and in Podolia, Kiev, Bessarabia, Kherson and Taurida, that is to say, southwestern Russia and the Roumanian border. Asia Minor was above the sea, and it is uncertain whether this last land mass extended to the northwest, or whether parts of Macedonia, Bulgaria, Serbia and Hungary constituted another large island. Ireland, Scotland and western England were above the sea, as was most of Spain and the site of the Pyrenees. There were smaller islands in the Alpine region and elsewhere in Italy, and a large island occupied the western Mediterranean, the latter sea reaching the Atlantic across southern Spain on the north and Morocco on the south.

The ancient rock-masses of Brittany and the Auvergne in France were land and it is uncertain whether or not the two were united across the Loire valley or whether the Atlantic fauna reached the Paris Basin across this area shown by broken lines on the map. Another large island extended from Norfolk across Flanders into Germany, and here also the map indicates by broken lines the uncertainty as to whether or not this island was connected with or separated from the island or islands on the site of Swabia, Franconia and northern Bavaria. The presence of traces of the Atlantic fauna in Germany has suggested that this fauna migrated in the northeasterly direction indicated by the arrow.

Along the southern border of this Swabian, Franconian, Bavarian island or islands, there were reefs, extending southwestward into France, which prevented the mingling of the Mediterranean fauna of the Danube Basin and Dauphiné with the Atlantic fauna of the Paris Basin. There were other extensive reef areas in the Alpine region, in Provence, and elsewhere at this time.

The horizontally lined areas on the map, Fig. 1, mark the range of the Atlantic or occidental fauna characterized by the ammonite genus *Pachyceras*. The NW.-SE. or diagonally lined

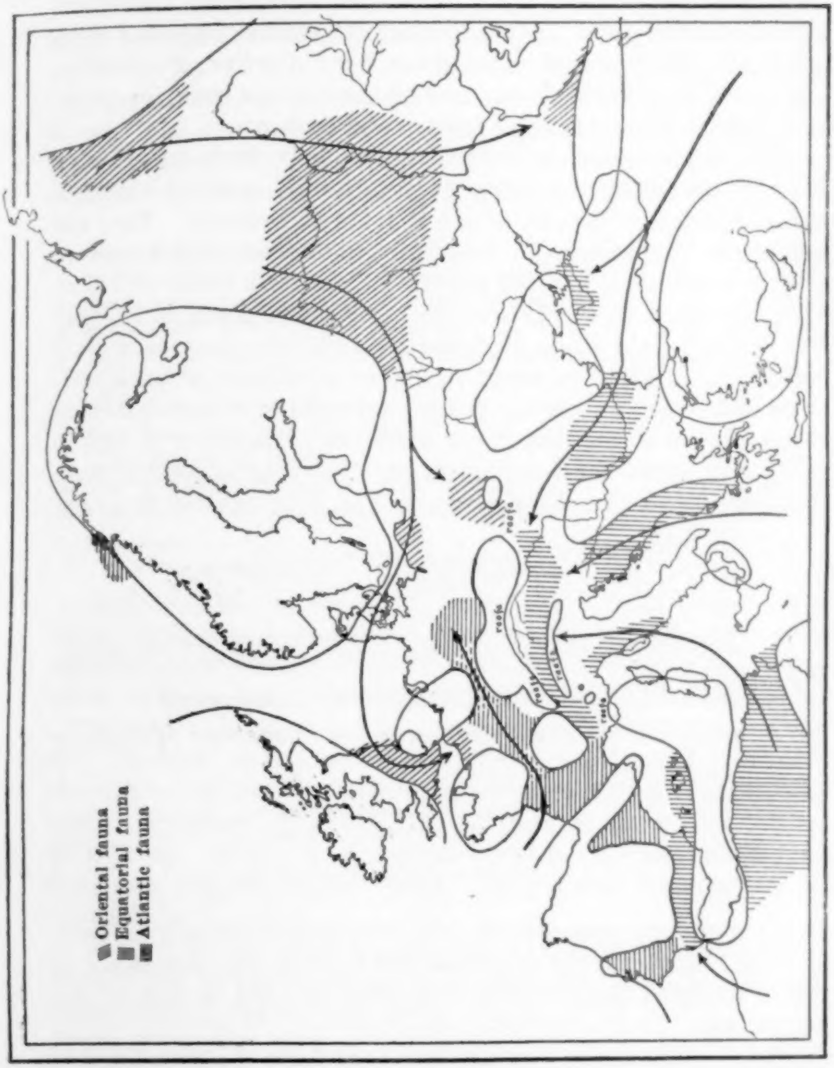

Fig. 1. Map of Europe Showing the Geography and Faunal Facies of the Portlandian. (Modified from DeLapparent and Haug.)

areas mark what is known as the Volgian[2] or oriental fauna with numerous species of *Virgatites* and other ammonites along with *Aucella, Rhynchonella, Belemnites, Exogyra, Cylindroteuthis,* etc., which probably migrated as I have indicated by arrows. This fauna was formerly (*e. g.,* by Naumayr) thought to be an Arctic or boreal fauna, but this view has now been rather generally and quite rightly abandoned. The vertically

[2] Named by Nikitin in 1881 from its development in the Volga Basin.

lined areas show the range of the equatorial or Tithonian[3] fauna characterized by the ammonite genera *Oppelia, Perisphinctes, Phylloceras, Lissoceras;* by *Collyrites, Berriasella, Waagenia* and *Aspidoceras,* and by the curious brachiopods of the genus *Pygope* (*Pygope janitor* and *diphya*).

The lithographic stone comes principally from quarries on the hills bordering the valley of the Altmühl, a small northern tributary of the Danube, which it joins at Kelheim. They extend from Pappenheim to Pfalzpaint, a distance of between 15 and 20 kilometers, and are about 65 kilometers south of Nürnberg and about 85 kilometers slightly west of north of Munich. The lithographic stone is found as lenticular masses with a maximum thickness of about 75 feet in what seem to be depressions or basins in a heavily bedded dolomite or magnesian limestone known as the Franconia dolomite. The latter is rich in corals and other reef-building forms. The graphic section from Pappenheim to Eichstädt shown in Fig. 2 brings out this rela-

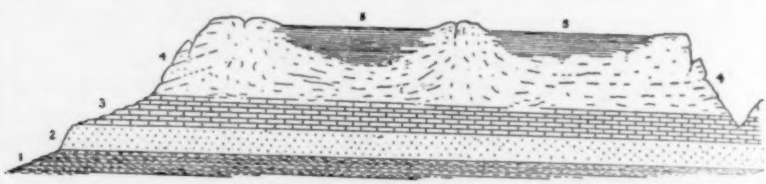

FIG. 2. DIAGRAMMATIC SECTION OF THE JURASSIC FROM PAPPENHEIM TO EICHSTÄDT. (After Walther.)

No. 1. *Aulacothyris impressa* marl
2. *Peltoceras bimammatus* beds
3. Kimeridgian sponge limestone
4. Franconia dolomite
5. Solnhofen lithographic stone

tionship and exposes several of the older and underlying beds.

No. 1 is called the *impressa* marls from the abundance of the brachiopod *Aulacothyris impressa* (Bronn) and is of Argovian age.

No. 2 is called the *bimammatus* beds from the abundance in it of the ammonite *Peltoceras bimammatus* and is of upper Oxfordian or Rauracian age.

No. 3 is a limestone, rich in sponges, known locally as the schwammkalk and is of Kimeridgian age.

No. 4 is the Franconia dolomite and is of lower Portlandian age.

No. 5 is the lithographic stone, or Solnhofener Plattenkalk, as it is called locally.

[3] Named by Oppel in 1865 from Tithon or Tithonius, the husband of Eos, the dawn, from its fauna which is prenuncial to that of the Cretaceous.

The actual relations, as seen in the field, are not as diagrammatic as might be inferred from the figure. Conditions of sedimentation varied greatly from place to place, some layers yielding the commercial lithographic stone, others merely building stone. The sequence of beds in an individual outcrop may be illustrated by the following section at Mörnsheim quarry, copied from Gümbel's "Geology of Bavaria" (1894, p. 816):

1.	Soil and sandy beds with ammonites	3 meters
2.	So-called fäule, rotten thin-bedded marly limestone	2 meters
3.	Thick limestone bank with flints and ammonites	4 meters
4.	Breccia-like beds rich in hornstone	1 meter
5.	Silicious calcareous shales rich in *Terebratula, Rhynchonella, Terebratella*, etc.	5 meters
6.	Rather massive siliceous limestone	5 meters
7.	So-called ironstone with 260 thin and 25 thicker lithographic stone layers	20 meters
8.	The so-called fäule, rotten marly limestone	10 meters
9.	Irregularly bedded limestone, the so-called bottom stone	5 meters
10.	Franconia dolomite. Total about	182 feet

Around Kelheim, where the Altmühl joins the Danube, the lithographic stone is replaced by a clayey coralline limestone which is known as the Diceras limestone because of the abundance of these heavy-shelled bivalves. These are found associated with a few ammonites (forms characteristic of the northwest German and French lower Portlandian and including *Olcostephanus portlandicus* and *O. gravesianus*), but many corals, echinoids, Nerineas, fishes, turtles, crocodiles, pterodactyls, etc. Coral sand is present and the cross-bedding of the sands and the shallow-water heavy shells indicate a considerable surf.

Postponing to a subsequent paragraph the description of some of the wonders preserved in the lithographic stone, such as the earliest known bird, the numerous flying lizards and the dinosaur fetus, it may be noted that the fossils collected comprise an unusual assemblage, and undoubtedly denote special conditions of sedimentation. Thus molluscs are comparatively rare; bottom dwellers are practically absent; open-sea pelagic forms are mixed with a host of lobster-like crustaceans; jelly fishes left the moulds of their radiating gastric cavities in the muddy ooze; while a variety of tracks, insects and terrestrial forms add to the confusion.

Walther, after a careful analysis of the fauna, interprets the conditions as those of coral atolls with lagoons whose muddy bottoms were partly exposed and partly tidal. The calcareous

ooze as well as most of the life forms, already dead, he regards as having been swept into these lagoons by storms or unusual tides, while the interbedded clay-ironstone is considered to be wind-blown dust from the mainland which, following von Gümbel, he locates some 25 kilometers to the south of the site of the deposits in the region of the present Vindelican Alps.

It would seem to me that these Jurassic reefs were fringing reefs, or keys like those of southern Florida, rather than that they were comparable to atolls. That the mainland was much nearer than 25 kilometers is indicated by the lack of strong flying powers in the fossil bird, of which two rather complete specimens as well as isolated feathers have been found. That these birds were not carried to their calcareous tombs by currents after their dead bodies had washed into the ocean, but that they habitually resorted to these mud flats for the variety of menu there offered, is indicated by certain tracks on the surface of the mud which appear to have been made by an immature bird before its primaries were fully grown.

If storms were responsible for the wealth of organic remains accumulated in such small compass, surely coral sand would be more in evidence, as it is at Kelheim, or erratic heads and fragments of the reef corals would be commoner in the muds. In the studies inaugurated by Drew[4] and continued by Vaughan and his associates for the Carnegie Institution it has been demonstrated that the calcareous muds of the Florida keys and the Bahamas are precipitates, due to the action of denitrifying bacteria that are normally present in warm sea water, and the presumption is very strong that most if not all muds of this sort, both recent and fossil, owe their existence to the activities of such bacteria.

This then would reasonably account for the calcareous ooze that made the lithographic stone.

That a part of these muds at Solnhofen were tidal is very probable, since otherwise it is difficult to account for the host of forms of the sea-drift that came to be buried in them, but there is no evidence of tidal scour or wave action, and the waters must have been quiet and for the most part very shallow. The Jurassic *Limulus* or horseshoe crab haunted these muddy bottoms just as his modern brother is found in similar situations along the present Florida coasts or in muddy coves in higher latitudes, and the water was quite enough to preserve the trails of some of these Jurassic horseshoe crabs as well as those of some of their associates.

[4] Publication No. 182, Carnegie Institution of Washington, 1914.

Millions of stalkless crinoids of the genus *Saccocoma* of at least three species swarmed in these shallow waters and ammonite shells have been found preserved in an upright and life-like position.[5] Since the water was shallow and the bottom flat, these submerged mud flats would necessarily be exposed twice a day over wide areas by tidal action, which operated in Jurassic times with the same seeming inexorable and invariable regularity that it does to-day. It is a familiar experience that animals stranded on such mudflats seem usually to have an oriental belief in "kismet" and are as passive as if already dead. This and the further fact that many animals that properly belong in the open sea or in deeper waters are found at Solnhofen, and which must have been floated into the lagoons in a dead condition, are more readily understood than Walther's elaborate explanation, especially when it is recalled that there were decades to spare for their accumulation. They would inevitably have been smashed and not preserved so perfectly if they had been swept over the reefs by storms.

Upwards of 500 different kinds of animals have been recorded from the lithographic stone, but this is somewhat swollen by the true German thoroughness that has given every problematical scrap a binomial Latin name. Despite this, the lists are imposingly long and marvellous in the variety of life that is represented. Insects to the number of over 100 kinds were blown upon the mud flats or perished in the waters; sometimes we have preserved in stone the traces of the struggles of some mired insect in its efforts to escape. There are no fresh-water forms of life. Fishes to the number of nearly 150 kinds, mainly ganoids, have been discovered in these rocks. The crustaceans, which number over 70 varieties, are mainly lobster-like forms. The ammonites number 19 species distributed among six genera, and there were large numbers of the Jurassic ancestors of our modern squids or cuttlefishes. These number 17 species distributed among 8 genera, and some of them were very common individually and undoubtedly lived in the lagoons. Very often more or less of their soft bodies as well as their vestigial shells and pens were preserved as, for example, in *Acanthoteuthis*, in which the ink bag and the ten arms with their double rows of hooks were fossilized. There were many sea worms, free-swimming crinoids (comatulids) and brittle stars, and even such perishable and aqueous objects as jelly fishes were preserved with great fidelity in the fine-grained

[5] Rothpletz, A., *Abh. k. Bayerischen Akad. Wiss.*, Vol. 24, pp. 311–337, 1910.

ooze, where they were stranded by the retreating tide. Bottom dwellers of the sea are mostly absent and are represented almost entirely by molluscs that were accidentally washed into the basins or voided by fishes. A single dinosaur, evidently bogged, has come to light. Several kinds of crocodiles have been found, all of the long slender-snouted gavial type, and there were several species of marine turtles. The vertebrate inhabitants of the air that occur in these deposits furnish the most weird elements in the landscape that I am endeavoring to picture.

By all odds the most spectacular find in the lithographic stone was the remains of the oldest known bird—the *Archæopteryx* or lizard-tailed bird. Its uniqueness may be indicated by the fact that it alone constitutes a subclass (Archæornithes), while all other known birds are grouped in a second subclass (Neornithes). A single feather found in 1860 was named by H. von Meyer and shortly afterward a fairly complete individual was found at Solnhofen in 1861 and acquired by the British Museum. The enormous price that was paid for this specimen stimulated the quarrymen to a sustained interest in fossils and in 1877 a second and better preserved specimen was discovered near Eichstädt and is now in the Berlin Museum. Owen, who monographed the British Museum specimen, called it *Archæopteryx macroura;* Dames, who monographed the Berlin Museum specimen, called it *Archæopteryx siemensi,* while the original feather described by von Meyer had already received the name of *Archæopteryx lithographica,* which therefore has priority.

The two individuals supplement one another and undoubtedly represent the same or closely related species. They constitute one of the few great landmarks in avian paleontology, since no other known form shows so many reptilian features.

Archæopteryx was about the size of a modern crow. The head was small and flat, with very large eyes, and without body feathers except on the back and nape. There was no beak and both jaws were armed with small sharp teeth set in grooves. The nostrils were well forward and the body was long and narrow. The vertebræ were bi-convex and about 50 in number, of which only 10 or 11 are regarded as cervical (the lowest number of cervicals in any modern bird is 13). Instead of the few caudal vertebræ of modern birds terminated by a pygostyle for the support of the digitately arranged tail feathers *Archæopteryx* had about 20 elongated tail vertebræ, each of which appears to have supported a pair of tail feathers or rectrices, whose arrangement may be said to have been pinnate as opposed

to the palmate arrangement of all other known birds. In the embryos of some existing birds the caudal feathers are the first to develop, the tail is relatively elongated and is said to show a pair of feather sacs for each vertebra. The hind legs were slender, wide apart and far back in position, but were otherwise much as in modern perching birds, except that the tibia and fibula were distinct, as in most reptiles. The wings were short and rounded, with three separate sharply clawed and functional fingers. The wings carried rather large flight feathers, of which six or seven pairs appear to have been primaries and ten secondaries, and there was at least one row of wing coverts. The three pelvic bones are perfectly distinct, as in most reptiles, and similarly the ribs lack the hook-like processes characteristic of modern birds.

The fine-grained mud has preserved the feathers of the tail and wings with remarkable fidelity and traces of an incipient ruff at the base of the neck and rather conspicuous quill-feathers on the legs. No traces of body or contour feathers have been discerned, so that it may be concluded that the body was naked or was covered with down or tiny feathers that were not resistant enough to be preserved.

There has been much speculation regarding the true nature and habits of *Archæopteryx* and several restorations have been attempted. That by Heilmann, while somewhat realistic, is entirely too heavily supplied with contour feathers, the tail is too massive, and the birds are depicted as tearing at a cycad cone, although they were undoubtedly carnivorous, as their teeth clearly indicate. From the position and slenderness of the legs Beddard supposed that *Archæopteryx* must have stood on all fours when on the ground, but this is in a measure negatived by the distinctly perching feet. Others have held that the absence of observable openings for the admission of air into the bones proved that *Archæopteryx* could fly only feebly if at all, but even such good modern flyers as swallows have practically nonpneumatic bones, and, moreover, we know that *Archæopteryx* resorted to the mud flats in search of food and hence must have flown from the mainland where it habitually dwelt. Finally, the well-developed feathering of the wings settles the question of flight beyond reasonable doubt. The labor of sustained flight with such short rounded wings may, however, have been compensated for by gliding, for which the wings and the quilled legs and distichous tail were admirably constructed and which historically must have preceded true flight. In an interesting

FIG. 3. RESTORATION OF THE EARLIEST KNOWN BIRD, *Archaeopteryx*

little article by Maurice Krosby,[6] from which I have copied the attitude, but not the details, of a flying *Archæopteryx*, it is implied that *Archæopteryx* had four wings; in fact, it is called *Tetrapteryx*, a name suggested by Beebe for the hypothetical ancestral bird.[7] Undoubtedly the quills on the legs made a plane of the hind legs, but they were not flapped, while the forelegs or true wings undoubtedly were flapped—the skeleton shows this much.

A comparison, rather remote, it is true, is suggested between the flight of *Archæopteryx* and that of the modern tinamous of South America, which have somewhat similar short rounded wings. As described by W. H. Hudson, the tinamous fly violently for a maximum distance of perhaps a mile, but usually a much less distance, and then glide to the ground, repeating this two or three times before becoming exhausted. The tinamous are ground dwellers and rapid runners, while *Archæopteryx* was, on the other hand, clearly a partially arboreal form and scarcely a runner. Its functional clawed fingers must have been habitually used in climbing about in the branches, much as a young hoactzin of South America does and they were also useful in effecting a safe landing in flying from one tree to another or at the end of a glide.

While *Archæopteryx* may be considered as about 25 per cent. reptilian, it is indubitably a true bird and a long way removed from its scale-covered and cold-blooded reptilian ancestors. There were bipedal bird-like reptiles already present before the close of the Triassic, so that there were some millions of years before the late Jurassic in which to evolve feathers and acquire the art of flying, and we know that the pterodactyls had successfully solved the problem of flight by another method in that same interval.

The present restoration (Fig. 3), which is believed to be far more accurate as to environment and detail than any heretofore attempted, shows the strand of the upper Jurassic mainland with the beach-ridges covered with a low jungle, made up largely of a mixed stand of cycads, with a few tall leathery fronded ferns, together with a scattering of taller conifers, comprising both scale-leafed (*Brachyphyllum, Palæocyparis*) and broad-leafed (*Araucaria*) types. High overhead is seen a small long-tailed pterodactyl or winged lizard (*Rhamphorhynchus*). In the foreground an *Archæopteryx* is flying. Note the slender body, the short heavily flapped wings, the pelvic plane made by

[6] *Popular Science Monthly*, Vol. 91, No. 1, 1917.

[7] *Zoologica*, Vol. 2, No. 2, pp. 39–52, 1915.

the widely spaced hind legs with their quill feathers, and the long distichously feathered tail constituting a second plane. At the right another *Archæopteryx* is shown with a small fish in its sharply toothed beakless jaws. It is perched on the crown of a *Zamites* of the *Williamsonia* order of cycadophytes. Note the long tail, the free clawed fingers of the fore limbs firmly grasping the cycad fronds and helping to sustain the long body.

Flying reptiles were evidently much more plentiful than birds during Solnhofen times, judging by the abundance and variety of their remains in these sediments, for nearly 30 different species have been described. They were weird bat-like creatures with pneumatic bones, large eyes, feeble hind limbs, and a keeled sternum for the attachment of the wing muscles like that of a modern flying bird. Their fifth finger had become enormously elongated and strengthened to support the membranous wings, which were thus exactly like the wings of a bat, with this exception, that only one instead of four fingers was elongated.

Ancestral pterodactyls go back at least as far as the Liassic or basal Jurassic. The Solnhofen forms were all relatively small and include over a score of species of the short-tailed *Pterodactylus* and five species of the long-tailed *Rhamphorhynchus*. Thus *Rhamphorhynchus phyllurus* had a total length of about 18 inches, of which two thirds was tail, and a wing spread of about 32 inches. An individual of the latter is shown, high in the air, in the accompanying restoration. Many thousands of years later, just before they became extinct, some of the pterodactyls lost their teeth and acquired bird-like bills and developed to gigantic size. Thus some of the pteranodons from the Upper Cretaceous Niobrara chalk of Kansas had a wing span of 18 feet, which is greater than that of any known bird.

Very many interesting tracks are preserved at Solnhofen, both those made on the emerged and on the submerged mud flats. These range from those of the Solnhofen *Limulus* or horse-shoe crab to that of an insect trying to extricate itself from the sticky mud, and include many that are problematical in character. One of the most well defined tracks that has been discovered and clearly that of some more or less bipedal vertebrate was early described and named *Ichnites lithographica* by Oppel. It consists of two rows of four-toed footprints at intervals of about 9 centimeters and about 7 centimeters between those of the right and left foot. Midway between the prints of the right and left foot is a small and shallow furrow of varying width and depth, apparently the trail of a dragging tail.

Alternating with the footprints and midway between them and the tail furrow are elliptical depressions with their long axes directed forward and outward. (This track is shown in Fig. 4.)

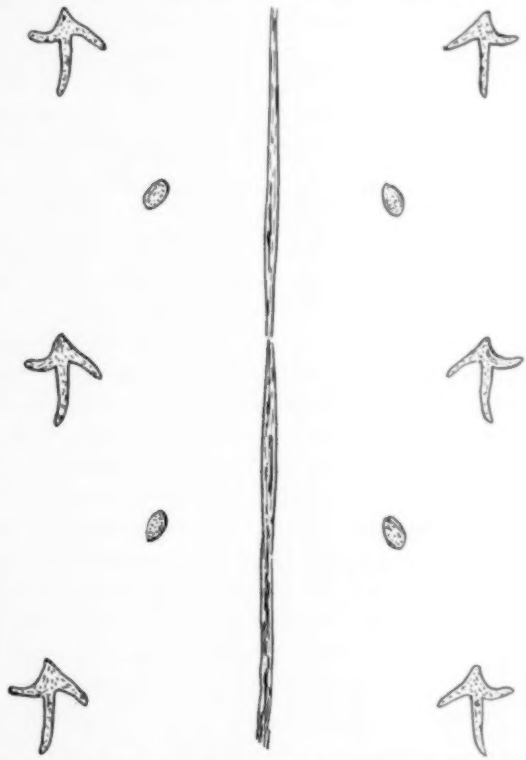

FIG. 4. PROBLEMATIC TRAIL, POSSIBLY OF AN IMMATURE *Archæopteryx*. (After Oppel.)

The question for decision is what sort of an animal made this track and how. Oppel thought that it was made by an *Archæopteryx* and many have followed him in this interpretation. Any small long-tailed animal with bird-like feet such as birds or some of the contemporaneous bird-like reptiles would readily account for the footprints and tail furrow, but how are the alternating elliptical tracks to be explained. They are too constant and regular not to have been made by the same animal that made the other parts of the trail. It has been commonly supposed that *Archæopteryx* made the whole trail by using its wings like a pair of crutches, the point of rest being the carpal or wrist joint. This is of course possible. Or it is possible that some other and as yet otherwise unknown animal made the tracks.

The chief objections to their having been made by a mature *Archæopteryx* are the small size of the footprints—much smaller than the feet of the two known specimens, the fact that the pinnately feathered tail would hardly leave a tail furrow in the mud that would look exactly like this one does, and that the wing quills would hardly permit of the wings being used as crutches. Nor is it easy to understand why the functional fore feet were not used. Moreover, if the weight rested on the wings, as assumed, the extremity would sink deep in the soft mud and hinder rather than help locomotion, as well as ruin the quills for purposes of flight. This would be equally true upon hard ground unless the quills were held in an unnatural way. It would further seem that if this were the true interpretation, the long slender body would demand that the ends of the wings rest farther apart. How the bird managed to hop at all, unless the wing-prints were one or more intervals in front of the corresponding footprints is difficult to understand. It is useless to deny the possibility of the accepted interpretation. I am, however, more inclined to think that while this trail belonged to *Archæopteryx*, it represents the trail of an immature and as yet practically flightless individual, which progressed in this way when on the ground—their small size might suggest this, and the difficulties about the wing and tail feathers would be obviated by their not having as yet become fully functional in size and possibly only sufficiently grown to permit gliding.

The terrestrial vegetation still remains to be considered briefly. Fossil plants have been known from Solnhofen since the days of Sternberg's "Flora der Vorwelt." In striking contrast to the variety and abundance of the animal remains, the traces of the former vegetation that clothed the near-by land are only occasionally met with in the lithographic stone, and even when present they are for the most part fragmentary.

The reasons for this absence of plants are to be found in the macerating action of the water, the non-deciduous character of the foliage of Jurassic plants, the activity of bacteria in the warm sea water, and most of all to the situation of the deposits, away from any estuary with its stream-borne load of land-derived débris. That these reasons are valid is corroborated by the fact that the few plants that have been discovered are such as have leathery decay-resisting parts such as cone scales and coniferous twigs, thus indicating that all the more delicate plant fragments had been destroyed, and by the additional fact that in other regions at this time where the sediments are more clearly of an estuary type as in the fish beds of

Cerin in France, a much more extensive flora as well as much disseminated vegetable matter and bitumen are present in the shales.[8]

The number of plant names in the literature would indicate that we knew a considerable flora from the lithographic stone, but a good many of these are names merely. Thus Saporta enumerated six coniferous species from Solnhofen, although at least half of these are now rightly regarded as synonyms of the remaining three. Similarly, Thistelton Dyer recorded 5 species of the coniferous genus *Athrotaxites,* although but one or two are valid.

Ignoring the doubtful impressions which have been described as seaweeds and which are without botanical value, there are at least four genera of Solnhofen ferns, so-called. The most abundant of these individually is *Lomatopteris jurensis* (Kurr) Schimper, and the others are forms of the genera *Sphenopteris, Odontopteris* and *Ungeria,* and some of them at least are not ferns, but relics of plants of the cycad or "sago-palm" alliance which frequently had fern-like fronds.

One of the most definitely identified plants is based on the characteristic one-seeded cone scales, which Dyer christened *Araucarites Häberleinii* and which unquestionably belong to the Eutacta section of the genus *Araucaria,* an antipodean group in the modern flora, but one that was world-wide in its Mesozoic distribution. Another satisfactorily determined conifer is *Brachyphyllum,* which has been entirely extinct since the Upper Cretaceous, but which was exceedingly ubiquitous throughout the Mesozoic. It had thick, club-shaped terete twigs with the leaves reduced to scales somewhat similar to those of a modern arbor vitæ or an incense cedar. Other twigs found at Solnhofen represent a cypress-like conifer variously called *Athrotaxites* or *Palæocyparis;* and *Ginkgo* and its extinct ally, *Baiera,* have also been identified, but with doubt, however.

The plants of these far-off Jurassic times are so different in every way from any that still survive that it is most difficult to picture their environment in terms of their physical requirements. We know that the climate was warm from the character of the calcareous ooze in which the fossils have been found. We presume that it was also humid from the kinds of contemporaneous terrestrial and arboreal animal life, and we also know that climates were more uniform then than now from the simple fact that the same Jurassic floras occur in the Arctic and Antarctic regions as are found in the equatorial zone.

[8] Saporta, G. de, *Ann. Soc. Agric. Lyon,* Vol. 5, pp. 87–142, pl. 14, 1873.

While it may be doubted if the reefs of Solnhofen supported a dense growth of vegetation, the mainland was more or less a jungle, although it was one prevailingly low in stature and one that might more appropriately be called a "scrub" or "bush." If we can imagine a chaparral made up of ferns and cycad-like plants with cypress-like conifers rising here and there above the general level, we shall have a fairly accurate picture of the Solnhofen woods. *Sequoia* cones have been found

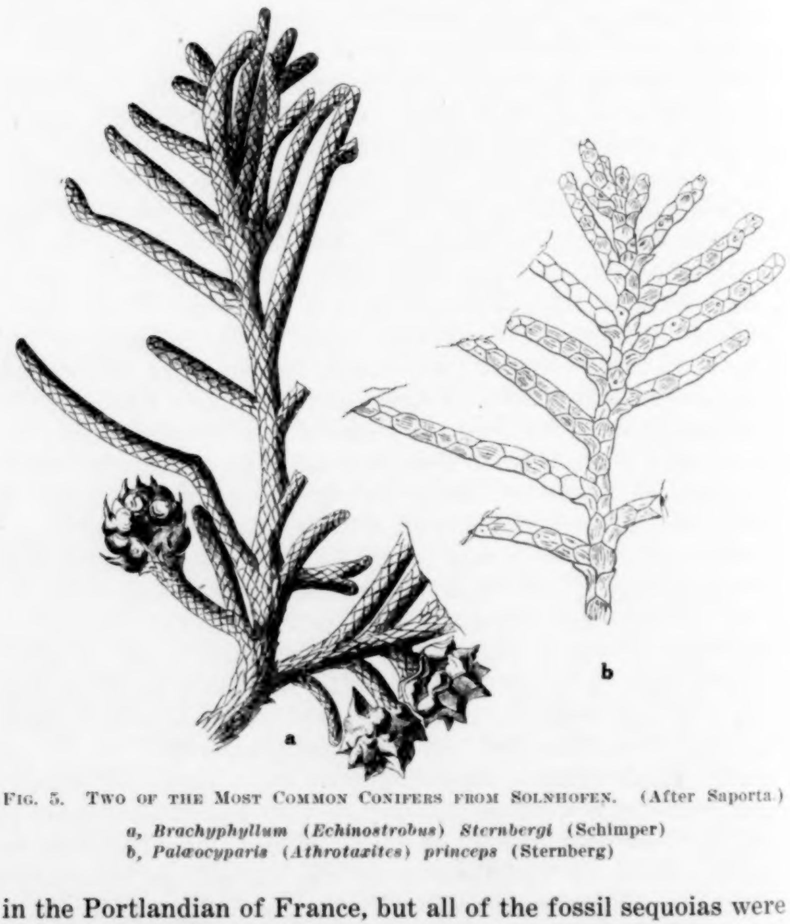

FIG. 5. TWO OF THE MOST COMMON CONIFERS FROM SOLNHOFEN. (After Saporta.)
a, Brachyphyllum (Echinostrobus) Sternbergi (Schimper)
b, Palæocyparis (Athrotaxites) princeps (Sternberg)

in the Portlandian of France, but all of the fossil sequoias were not giants like the California big trees. In Fig. 5 I have reproduced two of the commoner types of scale-leafed conifers that have been found in the lithographic stone, namely *Brachyphyllum* and *Palæocyparis.*

THE PROGRESS OF SCIENCE

RAPHAEL PUMPELLY'S REMINISCENCES

RAPHAEL PUMPELLY, distinguished as an explorer and geologist, has at the age of eighty-one years put through the press his reminiscences, well printed and illustrated, by Henry Holt and Company. It is an entertaining book, telling of many adventures in strange lands under conditions which no longer exist.

Even in central New York a child eighty years ago lived under frontier conditions. The family owned forests, farms and stores; the Susquehanna River and later the Erie Canal were the means of communication with the outside world. Pumpelly was sent to school in preparation for Yale College, but persuaded his mother to take him abroad, where in Germany, France and Italy there was a charm in travel which has largely vanished under modern conditions. The changes in Germany, for example, have been almost as great as in central New York and in Arizona. Then the cities were still medieval in character, grass grew in the streets, sanitation was lacking, industries were carried on chiefly by individual handicrafts, the people were simple and kindly.

Pumpelly's most exciting adventures were in Corsica, where he lived with the mountain people and became interested in geology. At Vienna he by chance attended a meeting of the German Association of Scientific Men, corresponding to our American Association for the Advancement of Science, and casually made the acquaintance of Professor Noeggerath, the Bonn geologist, who advised him to study at the Mining Academy at Freiburg in Saxony, where he spent three years.

On returning to America, after an absence of six years, Pumpelly went to Arizona to develop silver mines in the Santa Rita Mountains. The conditions in the desert with its Indians, Mexicans and outlaws seem almost incredible and were reduced to chaos by the removal of the United States soldiers at the outbreak of the Civil War. After countless adventures, Pumpelly made his way over the Old Yuma Trail to California. There he received an appointment to enter the Japanese service and had the advantage of intimate acquaintance with the country and its people when it was first opened to the outside world. He explored the mines and introduced the use of gun powder in blasting, but the anti-foreign party forced the Yeddo Government to cancel its contracts and Pumpelly went to China. There he received an imperial commission to examine the coal fields and had all sorts of adventures in regions practically unexplored and among natives to whom foreigners were almost unknown. Everywhere Pumpelly appears to have formed kindly relations with all sorts and conditions of people. He finally crossed Siberia and returned to New York at the age of twenty-eight.

Pumpelly accepted in 1866 a chair of mining geology at Harvard which he held for nine years. His first class consisted of William Morris Davis, Henry Gannett and Archibald Marvin. But he only spent a limited amount of time at Cambridge, being engaged in many enterprises and living in many places. He was on the U. S. Geological Survey, state geologist of Michigan and Missouri, and director of the Northern Transcontinental Survey. He was vice-president of the International Geological Congress, held in Washington in 1891. An illustration is here reproduced (by the courtesy of Henry Holt and Company to whom we are also indebted for permission to reprint the portrait of Pumpelly)

Raphael Pumpelly, 1900

From a photograph by Elise Pumpelly Cabot

showing four distinguished directors of foreign geological surveys, together with Dr. Van Hise and the author, on an excursion which followed the congress. But all these things are passed over lightly in the book. Pumpelly was most happy in his married life and had innumerable friends among scientific men and men distinguished in other directions; but he likes best to describe adventures among strange peoples.

This he does again toward the close of the book, for at the age of nearly seventy he conducted an expedition into Central Asia for the Carnegie Institution accompanied by his son, and with the cooperation of Professor W. M. Davis and Professor Ellsworth Huntington. They made important discoveries concerning prehistoric civilizations and geological and climatic changes. The next to last chapter tells of revisiting the Arizona desert in 1915. The final chapter discusses ancestry, heredity and environment.

THE USE OF ASPHYXIATING GAS

THE British Ministry of Information, according to the *British Medical Journal*, recently issued a communication relating to a statement sent out by the official German wireless to the effect that the idea of using poison gas in warfare originated with the British Admiral Lord Dundonald, better known to fame as Lord Cochrane. It is a matter of history that in 1812 Dundonald submitted to the Prince Regent, afterwards George IV., secret war plans which included the use of an asphyxiating gas. A committee of experts to whom this proposal was referred expressed the opinion that the mode of attack was "infallible and irresistible," but it was not sanctioned. In 1840, when there was a threat of war with France, Dundonald again submitted his plan to the British Government and offered by means of it to annihilate the French fleet. The Duke of Wellington thought well of the idea, but with his practical good sense pointed out that "two could play at that game," a fact which the Germans have learnt to their cost. In 1846 the plans were again referred to a committee, which reported that it was not desirable that any experiment should be made on the ground that part of the plans "would not accord with the principles of civilized warfare." Later, when again there was talk of war, Dundonald was asked about his plan, but once more it was rejected, the only objection to it being that it was "too terrible for use by a civilized community." Dundonald's account of the plan is given in the correspondence of Lord Panmure, who was War Minister during the Crimean War. In a memorial dated August 7, 1855, he states that when viewing some sulphur kilns in 1811 he observed that the fumes which escaped in the rude process of extracting the material, though first elevated by heat, soon fell to the ground, destroying all vegetation and endangering animal life to a great distance. With reference to the materials required for the expulsion of the Russians from Sebastopol, experimental trials had, he said, shown that about five parts of coke effectually vaporize one part of sulphur. Four or five hundred tons of sulphur and two thousand tons of coke would be sufficient. Besides these materials it would be necessary to have as much bituminous coal and a couple of thousand barrels of gas or other tar for the purpose of masking the fortifications to be attacked, with dry firewood to kindle the fires, which ought to be kept in readiness for the first favorable and steady breeze. Dundonald offered to direct the application of the plan himself, but the proposal was rejected. The use of asphyxiating gas is a very ancient device. Smoking out the enemy was one of the regular manoeuvres of war in antiquity. Polybius relates

Four Directors of Foreign Geological Surveys, 1891

Group with the directors of the Swiss, Russian, French, and Norwegian Geological Surveys.

that at the siege of Ambracia by the Romans under Marius Fulvius Nobilior (B.C. 189) the Ætolians filled jars with feathers which they set on fire, blowing the smoke with bellows into the face of the Romans in the countermines. At the great naval battle fought in the waters of Ponza between Alfonso of Aragon and Genoa in 1435 the Genoese carried vessels filled with quicklime and red-hot cinders, the smoke from which was blown by the wind against the enemy. Leonardo da Vinci, who among his many other accomplishments was a notable military engineer, suggested the use of poisonous powders, such as yellow arsenic and verdigris, to be thrown from the topmasts of ships so as to choke the enemy. This formed a part of the war instructions given by Leonardo to the Republic of Venice in 1499, when the Turks had passed the Isonzo and threatened St. Mark's.

THE STUDENT'S ARMY CORPS

THE possibilities of organization in our educated democracy are shown by the arrangements which have been made to train students for the army in our colleges and universities. Over four hundred institutions have placed their faculties, buildings and equipment at the service of the government and in each of these a student's corps will be in training after the first of October. In the eight institutions for higher education in New York City, there may be some 20,000 men in training. If there are half so many in other institutions throughout the country there would be 500,000 recruits from whom will be selected candidates for officers' commissions and technical posts in the army.

THE War Department advises all young men, who were planning to go to college this fall, to do so. Each should go to the college of his choice, matriculate and enter as a regular student. He will have registered with his local board and opportunity will be given for all the regularly-enrolled students to be inducted into the Students' Army Training Corps at the schools where they are in attendance. Thus the Corps will be organized by voluntary induction under the Selective Service Act, instead of by enlistment as previously contemplated. The War Department announces that the students become soldiers in the United States Army, uniformed, subject to military discipline and with the pay of a private. They will simultaneously be placed on full active duty and contracts will be made as soon as possible with the colleges for the housing, subsistence and instruction of the student soldiers.

The student-soldiers will be given military instruction under officers of the Army and will be kept under observation and test to determine their qualifications as officer-candidates, and technical experts such as engineers, chemists and doctors. After a certain period, each man will be selected according to their performance, and assigned to military duty in one of the following ways: (*a*) He may be transferred to a central officers' training camp. (*b*) He may be transferred to a non-commissioned officers' training school. (*c*) He may be assigned to the school where he is enrolled for further intensive work in a specified line for a limited specified time. (*d*) He may be assigned to the vocational training section of the corps for technician training of military value. (*e*) He may be transferred to a cantonment for duty with troops as a private.

Similar sorting and reassignment of the men will be made at periodical intervals, as the requirements of the service demand. It can not be now definitely stated how long a particular student will remain at college. This will depend on the requirements of the mobilization and the age group to which he belongs. In order to keep the unit at adequate strength, men will be admitted from secondary

schools or transferred from Depot Brigades as the need may require.

In view of the comparatively short time during which most of the student-soldiers will remain in college and the exacting military duties awaiting them, academic instruction must necessarily be modified along lines of direct military value. The War Department will prescribe or suggest such modifications. The schedule of purely military instruction will not preclude effective academic work. It will vary to some extent in accordance with the type of academic instruction, *e. g.*, will be less in a medical school than in a college of liberal arts. The primary purpose of the Students' Army Training Corps is to utilize the executive and teaching personnel and the physical equipment of the colleges to assist in the training of our new armies. This imposes great responsibilities on the colleges and at the same time creates an exceptional opportunity for service. The colleges are asked to devote the whole energy and educational power of the institution to the phases and lines of training desired by the government. The problem is a new one and calls for inventiveness and adaptability as well as that spirit of cooperation which the colleges have already so abundantly shown.

There will be both a collegiate section and vocational section of the Students' Army Training Corps. Young men of draft age of grammar school education will be given opportunity to enter the vocational section of the corps. At present about 27,500 men are called for this section each month. Application for voluntary induction into the vocational section should be made to the local board and an effort will be made to accommodate as many as possible of those who volunteer for this training. Men in the vocational section will be rated and tested by the standard Army methods and those who are found to possess the requisite qualifications may be assigned to further training in the collegiate section.

SCIENTIFIC ITEMS

WE record with regret the death of Samuel Wendell Williston, professor of paleontology in the University of Chicago; of Maxime Bôcher, professor of mathematics in Harvard University; of Dr. Byron D. Halsted, professor of botany in Rutgers College; of F. P. Treadwell, an American by birth, professor of chemistry at Zürich, and of J. Kollmann, professor of anatomy at Basel.

IT is officially announced that Yale University will receive, as residuary legatee of the late John W. Sterling, at least fifteen million dollars, which will nearly double the endowment of the university.

THE new National Museum has been closed to the public by the board of regents, as all available space in the building has been occupied by the Bureau of War Risk Insurance. It is expected that the museum will be again opened when the new office building of the bureau, at Vermont Avenue and H Street, is completed. —A temporary exhibition was opened in a few of the galleries of the British Museum on August 1. The exhibition galleries were closed by order of the government as a measure of economy in the spring of 1916, and, owing to the necessity of increased precautions against air raids, all the most valuable objects have been removed to places of greater safety. The trustees, however, have deeply regretted the closing of their doors to visitors, and especially to soldiers from the oversea Dominions. An exhibition has accordingly been arranged, consisting chiefly of casts and facsimiles, which it is hoped will both be instructive in itself and representative of some parts of the treasures of the British Museum.

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